

087030

JPRS-UPM-86-003

5 February 1986

# USSR Report

PHYSICS AND MATHEMATICS

19981109 134

**FBIS**

FOREIGN BROADCAST INFORMATION SERVICE

REPRODUCED BY  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
U.S. DEPARTMENT OF COMMERCE  
SPRINGFIELD, VA. 22161

1  
69  
A04

5 February 1986

USSR REPORT  
PHYSICS AND MATHEMATICS

## CONTENTS

## ACOUSTICS

- Branches of Acoustic Oscillations of a Gas Interacting in  
Resonance With Light  
(F. Kh. Gelmukhanov, L. V. Ilichev; ZHURNAL EKSPERIMENTALNOY  
I THEORETICHESKOY FIZIKI, No 3, Mar 85)..... 1

## CRYSTALS, GLASSES AND SEMICONDUCTORS

- Modulation of IR Lasers by Semiconducting Plasma  
(L. I. Berezhinskiy, A. I. Liptuga; KVANTOVAYA  
ELEKTRONIKA, Oct 84)..... 2
- Excitation Characteristics of Cascade Stimulated Radiation  
of Trivalent Lanthanides in Dielectric Crystals  
(A. A. Kaminskiy, V. A. Fedorov; DOKLADY AKADEMII  
NAUK SSSR, No 4, Apr 85)..... 2
- Investigation of Effect of Repeated Laser Irradiation on  
Active Laser Glasses  
(R. I. Andreeva, A. P. Kalagin, et al.; OPTIKO-  
MEKHANICHESKAYA PROMYSHLENNOST, No 1, Jan 85)..... 3
- Movement of Periodic Surface Microrelief Due to Powerful  
Laser Radiation  
(I. A. Avrutskiy, P. V. Bazakutsa, et al;  
KVANTOVAYA ELEKTRONIKA, No 3, Mar 85)..... 3
- Frequency-Doubling Efficiency of IR Radiation in Periodic  
Stratified Media  
(L. A. Bolshov, V. P. Reshetin; KVANTOVAYA  
ELEKTRONIKA, No 1, Jan 85)..... 4
- Gain Saturation in GLS22 Phosphate Neodymium Glass  
(V. N. Alekseyev, D. I. Dmitriyev, et al.; KVANTOVAYA  
ELEKTRONIKA, No 1, Jan 85)..... 4

## GAS DYNAMICS

- Numerical Analysis of Nonequilibrium Flow About Airfoil in Thin Shock Layer Approximation  
(V. N. Golubkin, V. V. Negoda; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 4, Apr 85)..... 5
- Shockwaves During Expansion of Compressed Volume of Gaseous Suspension of Solid Particles  
(B. E. Gelfand, A. V. Gubanov, et al.; DOKLADY AKADEMII NAUK SSSR, No 5, Apr 85)..... 5
- Numerical Solution of Problem on Decay of High-Temperature Region of Radiating Gas With Various Initial Internal Energy Distributions  
(V. P. Korobeynikov, B. V. Putyatin, et al.; DOKLADY AKADEMII NAUK TADZHIKSKOY SSR, No 11, Nov 84)..... 6
- Bleaching of Moving Polydispersed Aerosol by Laser Beam  
(V. K. Pustovalov, I. A. Khorunzhly; KVANTOVAYA ELEKTRONIKA, No 3, Mar 85)..... 6
- Possibility of Employing Pulse Systems to Obtain Cumulative High Speed Jets  
(S. I. Anisimov, A. L. Belikovich, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, No 5, Mar 85)..... 7
- Shockwave Propagation in Low-Temperature Carbon Plasma  
(A. M. Galkin, N. N. Sysoev, et al.; VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA, No 2, Mar-Apr 85)..... 7

## LASERS

- Analysis of Efficiency of Utilizing Alpha-Radiation to Pre-Ionize the Working Mixture in Gas Discharge Lasers and Amplifiers  
(N. G. Basov, V. A. Danilychev, et al.; DOKLADY AKADEMII NAUK SSSR, No 5, Apr 85)..... 8
- Argon Laser Employing Sectional Gas-Discharge Tube  
(P. G. Dalchenko, M. I. Dzyubenko, et al.; KVANTOVAYA ELEKTRONIKA, Oct 84)..... 8
- Future Possibilities of Free-Electron Laser  
(A. N. Lebedev; PRIRODA, No 9, Sep 84)..... 9
- Gas Discharge Absorber for Passive Mode Locking of  $Ar^+$  Laser  
(Kh. G. Gafurov, G. P. Krindach, et al.; DOKLADY AKADEMII NAUK TADZHIKSKOY SSR, No 11, Nov 84)..... 10

New Findings on Creation of Powerful Tunable Subpicosecond Solid-State Lasers (V. Vasilyauskas, A. Piskarskas, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 3, Mar 85).....	10
Influence of Electromagnetic Wave and Wiggler Fields Inhomogeneity on a Free-Electron Laser (A. V. Serov; KVANTOVAYA ELEKTRONIKA, No 3, Mar 85).....	11
Analysis of Chemical Pulse DF-CO <sub>2</sub> Laser Characteristics in Lasing and Amplification Modes (B. G. Bravyi, G. K. Vaskiev, et al.; KVANTOVAYA ELEKTRONIKA, No 3, Mar 85).....	11
Features of Ytterbium-Erbium Glasses Laser Excitation (A. G. Murzin, D. S. Prilezhaev, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	12
Effect of Pulse Dependent Discharge on Relaxing Gas Flow (V. A. Levin, V. V. Netesov, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	12
"IGLAN-3" Multibeam CW Gas-Discharge CO <sub>2</sub> Laser (G. I. Kozlov, V. A. Kuznetsov; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	13
Competition of Orthogonally Polarized Modes in Two-Mode CO <sub>2</sub> Laser (V. M. Yermachenko, V. N. Petrovskiy, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	13
Stochasticity and Regular Pulsations in Q-Switched Laser (M. V. Vashnestov, I. I. Peshko, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	14
Investigation of Electroionization Pulsed Carbon Dioxide Isotope Output Characteristics (S. V. Bardakovskiy, N. M. Bladimirova, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	14
Hysteresis Effects in Ar Laser With Nonlinear Absorber in the Cavity (Kh. G. Gafurov, D. P. Krindach; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	15
A Mathematical Model of the Radiation of a Multichannel Laser (N. D. Cherepenin; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	15

Lasing of XeCl, XeF and KrF Excimer Molecules in Two-Component Mixtures (N. G. Zubrilin, A. I. Milanich, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	16
Laser Employing Wavefront Converting Mirror With Q-Switching by Stimulated Brillouin Backscattering (V. S. Arakelyan, G. Ye. Rylov; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	16
High-Power CO <sub>2</sub> Electric Discharge Laser With Easily Ionized Substances Added (V. V. Apollonov, Yu. M. Vaskovskiy, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	17
Influence of IR Laser Pulse Duration and Shape on Dynamics of Coherent Excitation in Vibrational Molecular Mode (G. K. Paramonov, V. A. Savva; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	17
Generation of Picosecond Pulses in Monopulse-Pumped Dye Lasers (K. D. Yegorov, V. M. Petnikova, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	18
Barium-Vapor Pulsed Laser in Self-Heating Mode (A. A. Isayev, G. Yu. Lemmerman; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	18
Spatial, Temporal and Energy Characteristics of Copper-Vapor Laser Radiation (V. P. Belyayev, V. V. Zubov, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	19
Amplification of Pulsed Radiation in Regenerative TEA CO <sub>2</sub> Laser (V. T. Platonenko, V. D. Taranukhin; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	19
Energy and Spectral Characteristics of CW Electroionization CO <sub>2</sub> Laser With Cryogenically Cooled Working Mixture (A. P. Averin, N. G. Bosov, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	20
Comparative Analysis of Optically and Electronically Pumped Broadband Excimer Lasers (G. Marovski, A. V. Kanayev, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	20
Relative Resistance of Working Mixtures of Iodine Photo-Dissociation Lasers to Development of Enthalpic Raman Scattering (K. S. Korolkov, O. Nosach, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	21

Single-Frequency CW Lasing in Injection Laser Based on Terraced Heterostructure With External Dispersion Cavity (A. P. Bogatov, I. C. Goldobin, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	21
Wavelength Switching in Copper-Vapor Lasers (S. A. Zenchenko, V. I. Ivanov, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	22
Influence of Radiation Spectral Composition on Gain in Neodymium Glass (A. Ye. Danilov, V. V. Orlov, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	22
Tunable YAG:Nd <sup>3+</sup> Laser With Glancing Diffraction Grating (S. M. Gladkov, V. I. Kuznetsov; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	23
H <sub>2</sub> /F <sub>2</sub> Chemical Laser Initiated by Excimer Flashlamp (Ye. V. Gordon, V. I. Matyushenko, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	23
YAG:Er <sup>3+</sup> Cross-Relaxation Laser (V. A. Lobachev; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Jul 84).....	24
Spectral Characteristics and Selectivity of Vibrational Excitation on Molecules in IR Laser Field Under Conditions of Gas Dynamic Cooling (S. M. Nikiforov; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Nov 84).....	24
NUCLEAR PHYSICS	
Parameters of Focusing Optics of Laser Thermonuclear Reactor (N. G. Basov, N. I. Belousov, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	25
Nonequilibrium Effects and Structure of X-Ray Lines in Tokamak Plasma (V. G. Gontis, V. S. Lisitsa; FIZIKA PLAZMY, No 4, Apr 85).....	25
OPTICS AND SPECTROSCOPY	
Study of the Kinetics of Molecular Nitrogen by the Method of Wide-Band Coherent Antistokes Scattering of Light (A. A. Devyatov, S. A. Dolenko, et al.; DOKLADY AKADEMII NAUK SSSR, No 6, Apr 85).....	27

Possibility for Optimizing Thermal Interaction in a Moving Focusing Medium by Amplitude-Phase Correction (V. A. Vdovin, Yu. M. Sorokin, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	28
Nonlinear Optical Spectroscopy of Phonon Polaritons (Y. N. Polivanov; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Jun 84).....	28
Diagnosis of Populations and Relaxation Processes of Vibrational and Rotational States of Molecules in Gases by Coherent Anti-Stokes Scattering Spectroscopy (V. I. Fabelinskiy; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Aug 84).....	29
Resonant Frequencies of Gates in Spatially Dispersed Optical Media (M. V. Karasev, V. P. Academician, et al.; DOKLADY AKADEMIY NAUK SSSR, No 5, Apr 85).....	29
Nonlinear Ionization of Multi-Electron Atoms (N. B. Delone; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 3, Mar 85).....	30
Intense Beams of Cold Atoms for Laser Spectroscopy (V. I. Balykin, V. C. Letokhov, et al.; IZVESTIYA AKADEMIY NAUK SSSR: SERIYA FIZICHESKAYA, No 3, Mar 85).....	30
Diffraction Efficiency of Phase Holograms With Superimposed Exposures (M. K. Shevtsov; OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST, No 1, Jan 85).....	31
Diffraction Efficiency of Holographic Gratings With Symmetrical Profiles (L. A. Dmitrieva, I. V. Golubenko, et al.; OPTIKO- MEKHANICHESKAYA PROMYSHLENNOST, No 1, Jan 85).....	31
Determination of Optical Inhomogeneity of Cylindrical Bodies by Light Beam Deflection (Kh. K. Aben, S. I. Idnurm, et al.; OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST, No 1, Jan 85).....	32
Optimization Functions and Parameters of a System of Flat Mirrors (G. P. Sivtsov; OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST, No 1, Jan 85).....	32
Spatial Coherence of Optical Fields in Longitudinally Inhomogeneous Media With Square-Law Index of Refraction (S. G. Krivoshlykov, N. I. Petrov, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	33

Enhancing Efficiency of Atom Ionization by Pulsed Periodic Lasers (S. V. Andreev, V. I. Minshin, et al.; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	33
Types of Oscillations in Cavity With Self-Pumped Wavefront Converting Mirror (I. M. Beldyugin, M. V. Zolotarev; KVANTOVAYA ELEKTRONIKA, No 3(153), Mar 85).....	34
Possibility of Compensating Small-Scale Inhomogeneities by a Zernike Cell (V. Ye. Sherstebitov; No 1, Jan 85).....	34
Influence of Universal Intramolecular Interactions on Laser Radiation From Oxazine 17 (N. V. Korolkova, N. V. Kurokhtin; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	35
Shape Reversal and Reconstruction for Supershort Light Pulses (L. S. Telegin, A. S. Chirkin; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	35
Wind Refraction of Partially Coherent Light Beam (V. A. Aleshkevich, G. D. Kozhoridze, et al.; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	36
Radiation Focusing by Prism Raster (A. S. Dementyev, D. P. Domarkene; KVANTOVAYA ELEKTRONIKA, No 1, Jan 85).....	36
Dynamic Self-Focusing of Optical Radiation (A. P. Sukhorukov, V. A. Trofimov; VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA, No 2, Mar-Apr 85).....	37
Investigation of Fluorescence Kinetics of Dyes of Parametric Frequency Conversion (S. A. Pleshanov, V. V. Shuvalov; VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA, No 2, Mar-Apr 85).....	37
Optical Losses in IR Materials and Fiber Optic Lightguides in Emission Region of CO Laser (V. K. Sysoyev; AKADEMIYA NAUK INSTITUT OBSHCHEY FIZIKI, Apr 85).....	38



# PLASMA PHYSICS

Plasma-Resonant Discharge (Yu. Ya. Brodskiy, S. V. Golubev, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, No 3, Mar 85)....	39
Slow Combustion of Laser Plasma and Optical Charges (V. B. Fedorov; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Jul 84).....	39
Spectroscopy of Laboratory and Space Plasma With Oscillating Electrical Fields (E. A. Oaks; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Jul 84).....	40
Equilibrium States of Charged Electron Beams and Space Charge Compensation Processes (V. A. Malafayev; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Oct 84).....	41
Characteristics of Mandelstam-Brillouin Scattering in Laser Plasma With Moderate Light Flux Densities of $10^{12}$ - $10^{14}$ W/cm <sup>2</sup> (V. V. Aleksandrov, M. V. Brenner, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, No 3, Mar 85)....	41
Expansion of Cloud of Relativistic Protons in Magnetized Plasma (Ye. N. Kruchina, R. Z. Sagdeev, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, No 3, Mar 85)....	42
Estimates of Parameters of Hot Electrons During Beam Heating of Plasma in a Magnetic Field (B. N. Breizman, V. I. Yerofeev; FIZIKA PLAZMY, No 4, Apr 85).....	42
Conditions for Stabilization of Negative Ion Beam Ion-Ion Instability (V. P. Goretskiy, A. P. Nayda; FIZIKA PLAZMY, No 4, Apr 85).....	43
Two-Dimensional Kinetic Model of Hydrogen Macroparticle Evaporation in a Tokamak (B. V. Kuteyev, A. P. Umov, et al; FIZIKA PLAZMY, No 4, Apr 85).....	43
Ohm's Law and Heat Transport in Turbulent Relativistic Plasma (Yu. V. Arkhipov, F. B. Baimbetov; FIZIKA PLAZMY, No 4, Apr 85).....	44
Relativistic Effects During Compton Interaction of Strong Electromagnetic Radiation and Optically Thin Layer of Cold Plasma (Yu. I. Lysikov, FIZIKA PLAZMY, No 4, Apr 85).....	44

Plasma Flows in Divertor Regions of "Vint-20" Single-Pass Torsatron (V. K. Bocharov, Ye. D. Volkov, et al.; FIZIKA PLAZMY, No 4, Apr 85).....	45
Energy Confinement Time as Function of Large Radius in T-13 Tokamak (A. V. Abramov, V. I. Belashov, et al.; FIZIKA PLAZMY, No 4, Apr 85).....	45
Influence of Plasma Density in Homogeneity on Its Response to Pulse Sounding (A. A. Kuzovnikov, V. S. Sviridkina; VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA, No 2, Mar-Apr 85).....	46
Collision and Radiation Processes in Low-Temperature Plasma Involving Highly-Excited Atomic and Molecular States (V. S. Lebedev; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Mar 84).....	46
Electrical Discharge With Open Electron Drift (S. V. Rybalov; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Jan 84).....	47
Plasma Mechanism Underlying High Pressure Gas Breakdown (A. P. Broymann; AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI, Sep 84).....	47
SUPERCONDUCTIVITY	
Nonlinear Properties of Superconducting Point Contacts and Prospects for Use in Quantum Electronics (M. V. Danilenko, V. E. Derkach, et al.; KVANTOVAYA ELEKTRONIKA, Oct 83).....	48
NUMERICAL ANALYSIS AND ALGORITHMS	
Method for Constructing Equivalent and $\epsilon$ -Equivalent Problems With One Constraint for a Nonlinear Discrete-Programming Problem (A. A. Aliyev, K. Sh. Mamedov; DOKLADY AKADEMII NAUK AZERBAJDZHANSKOY SSR, No 3, Mar 85).....	49
Use of Spectral Systems Run Coefficients for Spectral Estimation of Some Matrices (N. A. Ismailova, V. E. Kondrashov; DOKLADY AKADEMII NAUK SSSR, No 6, Apr 85).....	55

High Precision Algorithms for Solving First Order Integral Equations (A. Ye. Korovochkin, N. A. Marchenko, et al.; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 4, Apr 85).....	55
Two-Group Optimization for Method of Statistical Modeling of Radiation Field for Hydrogen Containing Media (S. M. Yermakov, V. V. Karyukin; ZHURNAL VYCHISLITELNOY MATEKATIKI I MATEMATICHESKOY FIZIKI, No 4, Apr 85).....	56
Letter to the Editor in Response to Article Entitled "Estimation of Function by Randomized Observations" (A. I. Koryakin; ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI, No 4, Apr 85).....	56
Dissipative Structures in Laser Radiation Field (N. A. Kirichenko; IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA, No 3, Mar 85).....	57

## ACOUSTICS

### BRANCHES OF ACOUSTIC OSCILLATIONS OF A GAS INTERACTING IN RESONANCE WITH LIGHT

Moscow ZHURNAL EKSPERIMENTALNOY I THEORETICHESKOY FIZIKI in Russian Vol 88, No 3, Mar 85 (manuscript received 9 Jul 84), pp 733-740

GELMUKHANOV, F. Kh. AND ILICHEV, L. V., Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences

[Abstract] The influence of light pressure, light-induced drift, and related effects on branches of acoustic oscillations of a gas in a radiation field is investigated. The role of light pressure in forming the acoustic oscillation spectrum is investigated in pure form by disregarding light induced drift and related effects. The effect of light induced drift on oscillations is then investigated by disregarding the recoil effect. The propagation frequencies and velocities of acoustic oscillations are estimated. It is found that the frequency of acoustic oscillations caused by the recoil effect is  $10^3 \text{ sec}^{-1}$ . The radiation-induced pressure tensor and heat flux result in two additional oscillation branches. References 13: 11 Russian, 2 Western. [386-6900/12955]

CRYSTALS, GLASSES AND SEMICONDUCTORS

UDC 621.373.826

MODULATION OF IR LASERS BY SEMICONDUCTING PLASMA

Kiev KVANTOVAYA ELEKTRONIKA in Russian Vol 27, Oct 84 (manuscript received 28 June 83), pp 50-54

BEREZHINSKIY, L. I. AND LIPTUGA, A. I., Institute of Semiconductors, Ukrainian SSR Academy of Sciences

[Abstract] The properties are investigated of a semiconductor modulator employing a nonequilibrium plasma stimulated by hybrid electrical and magnetic fields. An InSb crystal is investigated in hybrid fields at 195 and 300 K, and exhibits the voltage-current characteristics of a rectifier diode, indicating an unsteady total number of carriers in the crystal. It is found that significant surface enrichment can be achieved by using hybrid fields. It is found possible to modulate the radiation with a modulation coefficient the order of 80% and speed of  $10^{-8}$  seconds by controlling the concentration of the electron-hole plasma on an InSb surface. The region of wavelengths that can be modulated is determined by the limits of variation of the carrier concentration on the reflecting facet of the crystal. The method provides better speed, lower electrical field control voltages, and a wider spectral range of wavelengths that can be modulated than do other approaches. References 5: 3 Russian, 2 Western. Figures 5.  
[395-6900/12955]

UDC 548.0-535.35

EXCITATION CHARACTERISTICS OF CASCADE STIMULATED RADIATION OF TRIVALENT LANTHANIDES IN DIELECTRIC CRYSTALS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 281, No 4, Apr 85 (manuscript received 8 Aug 84), pp 838-841

KAMINSKIY, A. A. AND FEDOROV, V. A., Institute of Crystallography imeni A. V. Shubnikov, USSR Academy of Sciences

[Abstract] The characteristics of stimulated emission in cascade schemes are analyzed for multilevel systems of  $\text{Ln}^{3+}$  activators in dielectric crystals.

The properties of two inter-multiplet channels is investigated. Kinetic equations are derived for the local population. The transitions in a generalized five-level schema of  $\text{Ln}^{3+}$  ions and crystals is examined. References 14: 10 Russian, 4 Western. Figures 1.  
[381-6900/12955]

UDC 621.315.592

#### INVESTIGATION OF EFFECT OF REPEATED LASER IRRADIATION ON ACTIVE LASER GLASSES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 9 Apr 84), pp 14-17

ANDREEVA, R. I., KALAGIN, A. P., NIKOLAEV, V. N. AND TOROPKIN, G. N.

[Abstract] The occurrence and principles of defect accumulation in glasses with different bases are investigated. Experimental data on the time elapsed prior to breakdown for different laser radiation densities is analyzed. A single-mode single-frequency Q-modulated laser was employed to irradiate silicate and phosphate  $\text{Nd}^{3+}$  activated glasses. The accumulation and breakdown processes were found to occur on defects with different laser defect thresholds. The characteristics of the phosphate and silicate-based glasses examined are indistinguishable. The time elapsed prior to breakdown in glass subjected to repeated laser radiation is described by a log-normal distribution. References 10: 7 Russian, 3 Western. Figures 4.  
[383-6900/12955]

UDC 621.373.826

#### MOVEMENT OF PERIODIC SURFACE MICRORELIEF DUE TO POWERFUL LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3 (153), Mar 85 (manuscript received 16 Jul 84), pp 650-652

AVRUTSKIY, I. A., BAZAKUTSA, P. V., PROKHOROV, A. M. AND SYCHUGOV, V. A.,  
Institute of General Physics, USSR Academy of Sciences

[Abstract] Slow movement of the periodic structure produced on the surface of germanium by strong laser radiation is described. This phenomenon results from nonuniform energy loss, which causes deeper corrugation, with the phase shift resulting in symmetrical deepening of the corrugation, or "movement". The relationship between the phase shift and the angle of incidence of the perturbing radiation is calculated for different substances, showing that the direction of "movement" of the corrugation changes when the angle of incidence changes, and that there exists an angle  $\theta_0$  for which corrugation should develop without movement. This angle depends upon the coefficient of refraction and the coefficient of absorption of the material. References 3: 2 Russian, 1 Western. Figures 4.  
[397-6900/12955]

## FREQUENCY-DOUBLING EFFICIENCY OF IR RADIATION IN PERIODIC STRATIFIED MEDIA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85 (manuscript received 4 April 83), pp 108-114

BOLSHOV, L. A. AND RESHETIN, V. P., Institute of Heat- and Mass-Exchange imeni A. V. Lykov, Belorussian SSR Academy of Sciences

[Abstract] This study investigates the basic principles of nonlinear interaction among waves in a sandwich of transparent nonlinear crystals using second-harmonic lasing. The conditions for quasisynchronous wave interaction in a periodic layered structure in which the gradient of the indices of refraction between two adjacent layers is random are investigated. It is indicated that a sandwich of optically isotropic crystals can be employed for second-harmonic conversion of a laser beam with arbitrary polarization. The periodic structures investigated can be employed as ultraviolet or infrared frequency multipliers. Good conversion efficiency can be achieved in stratified media by using a large number of transparent crystals whose contributions to the second-harmonic are coherent. Figures 1, references 14: 9 Russian, 6 Western.

[274-6900/12955]

## GAIN SATURATION IN GLS22 PHOSPHATE NEODYMIUM GLASS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85 (manuscript received 12 March 84), pp 159-161

ALEKSEYEV, V. N., DMITRIYEV, D. I., ZHILIN, A. N. AND CHERNOV, V. N.

[Abstract] This study describes the gain saturation of GLS22 phosphate glass, which holds more promise than traditional silicate glasses for use in multi-stage amplifiers because of its lower thermal optical distortions and large induced transition cross-section. Beam energy density of  $8 \text{ J/cm}^2$  is achieved at the amplifier output. The saturation energy density is found to be independent of the pulse length and of the beam energy density so that the relaxation time of the lower lasing level is shorter than 1 nsec. It is noted that linear losses in the glass can usually be disregarded because they are so small. Figures 2, references 13: 9 Russian, 4 Western.

[274-6900/12955]

GAS DYNAMICS

UDC 519.6:533.6.011

NUMERICAL ANALYSIS OF NONEQUILIBRIUM FLOW ABOUT AIRFOIL IN THIN SHOCK LAYER APPROXIMATION

Moscow ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 25, No 4, Apr 85 (manuscript received 29 Mar 84 after revision) pp 599-608

GOLUBKIN, V. N. AND NEGODA, V. V.

[Abstract] The problem of hypersonic nonequilibrium flow about the windward surface of a short thin airfoil is examined in the first approximation of the thin shockwave method, employing the ratio of the densities on the shock-wave as the small parameter. A numerical solution method developed especially for the present class of problems is described. The necessary condition for stability of the scheme is found, and ways of improving the stability are proposed. The use of the method for analyzing the flow about a flat airfoil with a hyperbolic profile is described. References 9: 7 Russian, 2 Western. Figures 6.

[388-6900/12955]

UDC 532.529.5/6:533.6.011.72:534.222.2

SHOCKWAVES DURING EXPANSION OF COMPRESSED VOLUME OF GASEOUS SUSPENSION OF SOLID PARTICLES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 281, No 5, Apr 85 (manuscript received 28 Apr 84), pp 1113-1116

B. E. GELFAND, A. V. GUBANOV, S. P. MEDVEDEV, E. I. TIMOFEYEV AND S. A. TSYGANOV, Institute of Chemical Physics, USSR Academy of Sciences

[Abstract] The influence of solid particles suspended in a gas medium at high pressure on the parameters of shockwaves in the surrounding atmosphere is investigated experimentally in a shock tube. It is found that the occurrence of waves with smaller intensity and greater duration should be expected for detachment of high pressure vessels filled with a suspension of particles in a gas than for detachment of high pressure vessels containing gas alone. References 6: 3 Russian, 3 Western. Figures 2.

[396-6900/12955]



## NUMERICAL SOLUTION OF PROBLEM ON DECAY OF HIGH-TEMPERATURE REGION OF RADIATING GAS WITH VARIOUS INITIAL INTERNAL ENERGY DISTRIBUTIONS

Dushanbe DOKLADY AKADEMII NAUK TADZHIKSKOY SSR in Russian Vol 27, No 11, Nov 84 (manuscript received 21 May 84), pp 633-636

KOROBAYNIKOV, V. P., PUTYATIN, B. V. AND SHARIPOV, A. K., Mathematics Institute imeni V. A. Steklov, USSR Academy of Sciences, Higher Engineering Fire and Technical School, USSR Ministry of Internal Affairs, Mathematical Institute and Computer Center, Tadzhik SSR Academy of Sciences

[Abstract] The decay of the high temperature region of a radiating gas is investigated as a problem which models the process independently of the nature of the energy release source. Radiation gas dynamic equations are integrated numerically. Model step functions of the thermodynamic parameters are used for the coefficient of absorption and the radiation source function. Examples of the space-time distribution of the gas characteristics are presented. It is found analytically that the solutions to the problem for different types of initial internal energy distributions are practically the same when the dimensions of the heat release region are small enough. The role of the initial perturbation forms on the nature of the solution is examined. References 9: 7 Russian, 2 Western. Figures 1. [387-6900/12955]

## BLEACHING OF MOVING POLYDISPERSED AEROSOL BY LASER BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3 (153), Mar 85 (manuscript received 28 August 84 after revision), pp 594-602

PUSTOVALOV, V. K. AND KHORUNZHLY, I. A., Polytechnical Institute, Minsk

[Abstract] Bleaching of a moving polydispersed aqueous aerosol by laser radiation is analyzed by examining the evaporation of single droplets on a computer. The influence of the velocity of the aerosol, the radiation power, the intensity distribution over the beam cross-section, and the initial distribution function parameters for the polydispersed aerosol droplets' dimensions on the bleaching process is examined. Comparison of the findings with experimental results shows satisfactory agreement. References: 8 Russian. Figures 4. [397-6900/12955]

# POSSIBILITY OF EMPLOYING PULSE SYSTEMS TO OBTAIN CUMULATIVE HIGH SPEED JETS

Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian  
Vol 41, No 5, 10 Mar 85 (manuscript received 17 Jan 85), pp 191-193

ANISIMOV, S. I., BELIKOVICH, A. L., KOVALSKIY, N. G., LIBERMAN, M. A. and  
PERGAMENT, M. I., Institute of Physical Problems, USSR Academy of Sciences

[Abstract] A method is proposed for obtaining cumulative streams by ablating hollow cones from the outside. This method provides greater speeds than direct ablation acceleration. The use of lasers, electron beams, ion beams, charged particle beams and Z-pinch discharges to form cumulative high speed jets is described. References 8: 4 Russian, 4 Western.  
[368-6900.12955]

UDC 533.6.011.72

# SHOCKWAVE PROPAGATION IN LOW-TEMPERATURE CARBON PLASMA

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA in  
Russian Vol 26, No 2, Mar-Apr 85 (manuscript received 6 June 84), pp 77-80

GALKIN, A. M., SYSOEV, N. N. AND SHUGAEV, F. V.

[Abstract] The transformation of a shockwave front propagating through, and exiting from, an inhomogeneous region consisting of a carbon laser flame is investigated. The experiments with flat and spherical shockwaves in a square shock tube are described. The carbon plasma is formed by focusing ruby laser radiation on a carbon target in the working section of the shock tube. The different stages of interaction between the shockwaves and the carbon flame are registered visually by shadow techniques and an interferometer. The shockwave outside the region of the flame exhibits a near-spherical front; after passing through the plasma produced by the previous pulse, the shockwave accelerates, delaminates, and disappears. The disappearance is interpreted as resulting from the strong turbulence of the region through which it propagates. In general, shockwave propagation is similar to that of a plane wave along a heated surface. References 5: 3 Russian, 2 Western.  
Figures 3.  
[389-6900/12955]

## LASERS

UDC 539.18

### ANALYSIS OF EFFICIENCY OF UTILIZING ALPHA-RADIATION TO PRE-IONIZE THE WORKING MIXTURE IN GAS DISCHARGE LASERS AND AMPLIFIERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 281, No 5, Apr 85  
(manuscript received 20 Dec 84), pp 1106-1110

ACADEMICIAN N. G. BASOV, V. A. DANILYCHEV, V. N. KOTEROV, S. G. PERLOV, T. M. PLYSHEVSKAYA, A. M. SOROKA, USSR Academy of Sciences Corresponding Member  
N. D. CHEBURKIN, P. GLOTOV, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] This study investigates the spatial distribution of the laser mixture ionization rate by alpha-particles from a radioactive isotope layer. Conditions are identified under which the homogeneity of ionization by alpha-particles is as good as for electron ionization. The possibility of using electroionization excitation, in which the conductivity of the discharge plasma is maintained only by the external ionization source, is discussed. A discharge interval formed by two flat electrodes is analyzed as an example, assuming that the alpha-radioactive preparate is applied directly to both electrodes. The volumetric frequency of the gas ionization achieved near the electrodes, and the degree of inhomogeneity of the ionization frequency, are investigated as a function of the width of the discharge interval. The volumetric ionization frequency must be increased by approximately two orders of magnitude in order to employ electrode ionization excitation, which can be done by using alpha-radioactive isotopes with lifetimes of approximately one year. References 9: 7 Russian, 2 Western. Figures 2.  
[396-6900/12955]

UDC 621.378.33

### ARGON LASER EMPLOYING SECTIONAL GAS-DISCHARGE TUBE

Kiev KVANTOVAYA ELEKTRONIKA in Russian Vol 27, Oct 84 (manuscript received 30 March 83), pp 47-50

DALCHENKO, P. G., DZYUBENKO, M. I. and SHEVCHENKO, V. V., Institute of Radiophysics and Electronics, Ukrainian SSR Academy of Sciences

[Abstract] The influence is investigated of the discharge of conditions (the working gas pressure, discharge current, and value of the external axial

magnetic field) on the parameters of an argon laser employing a large-diameter capillary designed for pumping CW organic dye lasers. It is found that the optimum working gas density, and consequently, the optimum radiation density, is several times higher in large diameter gas discharge tubes than in small diameter ones; the discharge is more stable, and the heat loads are smaller, which increases the service life of the discharge capillary and the electrodes. A sectional tube made of aluminum discs insulated by heat-resistant rubber inserts is described. The basic energy characteristics of the lasers are investigated with cavities with near-semiconfocal configuration. The argon laser developed was used successfully to pump a rhodamine 6G CW laser tunable between 570 and 630 nm. References 9: 7 Russian, 2 Western. Figures 2.

[396-6900/12955]

#### FUTURE POSSIBILITIES OF FREE-ELECTRON LASER

Moscow PRIRODA in Russian No 9, Sep 84 pp 28-36

LEBEDEV, A. N., doctor of physical and mathematical sciences, Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The free-electron laser is a new source of coherent short-wave radiation. This new radiation source is quite different from ordinary lasers in which the emitted electrons are bound in an atom, molecule or in the crystal lattice. In principle, the operation of the free-electron laser has nothing (or almost nothing) in common with quantum physics in that the working medium (and at the same time, the energy source) is a beam of relativistic electrons conforming to the laws of classical mechanics. The free-electron laser is in essence a modification of traditional instruments used in microwave electronics. However, it is a fundamental innovation which makes it possible to advance into the infrared, visible and possibly the ultraviolet parts of the spectrum. This review article discusses the theoretical and practical aspects of this new technology. As an authority on accelerators, the author foresees a difficult road ahead in solving many of the problems which are involved in realizing all the theoretical possibilities which free-electron lasers promise. His sceptical point of view, however, is tempered by his recollection that accelerators have overcome an enormous number of difficulties during the last 20 years. After discussing the many problems which must be solved, and after noting that only a few experimental models of free-electron lasers operable in the infrared and optical ranges have been described in the literature at this time, he concludes that these difficulties can and will be overcome. Figures 6.

[79-5303/12955]

GAS DISCHARGE ABSORBER FOR PASSIVE MODE LOCKING OF  $\text{Ar}^+$  LASER

Dushanbe DOKLADY AKADEMII NAUK TADZHIKSKOY SSR in Russian Vol 27, No 11, Nov 84 (manuscript received 6 July 84), pp 648-651

GAFUROV, Kh. G., KRINDACH, G. P., NAZAROV, B. I. AND ROMANYUK, A. K.  
Physical-Technical Institute imeni S. U. Umarov, Tadzhik SSR Academy of Sciences, Moscow State University imeni M. V. Lomonosov

[Abstract] The possibility of using saturating absorbers for ion lasers is analyzed. Gas absorbers are found to be superior to dye for passive mode-locking in gas lasers. A gas discharge absorber is described which consists of a GL-301 gas discharge tube with an active section 15 cm long. Absorption at 488 nm is determined by the argon pressure, the diameter of the discharge channel, and the amount of discharge current. Average mode-locked power of approximately 0.3 W is obtained with pulse duration of 90 nsec. Pulse repetition intervals ranging from 6 to 14 nsec are achieved, with stability of the interval between pulses of at least  $2 \cdot 10^{-5}$ . References 8: 5 Russian, 3 Western. Figures 3.  
[387-6900/12955]

## NEW FINDINGS ON CREATION OF POWERFUL TUNABLE SUBPICOSECOND SOLID-STATE LASERS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 3, Mar 85, pp 493-499

VASILYUSKAS, V., PISKARSKAS, A., SIRUTKAITIS, V., STABINIS, A. AND YANKAUSKAS, A., Vilnius State University imeni V. Kapsukas

[Abstract] The use of parametric interaction of light pulses in media with quadratic nonlinearity to generate high-power frequency-tunable femtosecond pulses is examined. Pulse compression during strong energy exchange and dispersion blurring is modeled dynamically. Phase modulation of the radiation from superluminescent picosecond parametric lasers is investigated experimentally. It is found that the maximum nonlinear index of refraction in  $\text{LiNbO}_3$  crystals obtainable with pumping power densities sufficient for parametric lasing in the picosecond range is approximately an order of magnitude smaller than that required for linear frequency sweeping. These characteristics may also occur for second-harmonic pumping of a neodymium-phosphate glass picosecond laser, making it possible to obtain femtosecond pulses. References 15: 6 Russian, 9 Western. Figures 6.  
[382-6900/12955]

UDC 621.373.826.038.823

INFLUENCE OF ELECTROMAGNETIC WAVE AND WIGGLER FIELDS INHOMOGENEITY ON A  
FREE-ELECTRON LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85,  
(manuscript received 9 Apr 84), pp 516-521

SEROV, A. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The influence of cross-sectional wave and undulator fields inhomogeneity on the particle dynamics and gain of free-electron lasers is investigated. A new operating mode is examined in which either the transverse velocities of the beam particles, or their transverse coordinates, are modulated to the frequency of the amplified wave prior to injection into the undulator. The efficiency of electron energy conversion to radiation is investigated when the initial conditions for electron injection into the laser undulator are modulated. Modulation of the initial injection conditions makes it possible to exploit the value difference between the fields interacting with the accelerated and retarded particles, in order to increase average beam energy losses. References 15: 14 Russian, 1 Western. Figures 3.  
[397-6900/12955]

UDC 621.373.826.038.823

ANALYSIS OF CHEMICAL PULSE DF-CO<sub>2</sub> LASER CHARACTERISTICS IN LASING AND AMPLIFICATION MODES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 10 Apr 84), pp 522-531

BRAVYY, B. G., VASKIEV, G. K. AND KIRYANOV, V. I., Institute of Chemical Physics, USSR Academy of Sciences

[Abstract] The characteristics of a pulse chemical DF-CO<sub>2</sub> laser in the free-lasing and amplification modes are analyzed on the basis of experimental and analytical data. Good agreement is found for free lasing with initiation far from the lasing threshold. The characteristic rotational relaxation time of the CO<sub>2</sub> molecule is refined, and found to be twice that cited in the literature. The experimental and calculated lasing initiation and termination times agree well, indicating that the chemical reaction description is correct, at least for mixtures with a composition close to 5% D<sub>2</sub> -- 15% F<sub>2</sub> -- 25% CO<sub>2</sub> -- 1% O<sub>2</sub> -- 54% He. Vibrational distribution in the CO<sub>2</sub> molecule is found to be non-Boltzmann in the amplification mode, which is interpreted as resulting from the saturated radiation pulse passing through the amplifying medium. References 55: 20 Russian, 35 Western. Figures 6.  
[397-6900/12955]

## FEATURES OF YTTERBIUM-ERBIUM GLASSES LASER EXCITATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 16 Apr 84), pp 532-539

MURZIN, A. G., PRILEZHAEV, D. S. AND FROMZEL, V. A.

[Abstract] This study examines inverse population accumulation at the  $^4I_{13/2}$ - $^4I_{15/2}$  resonant transition of  $Er^{3+}$  ions in ytterbium-erbium glasses of various composition. Methods are examined for measuring the parameters of forward and reverse excitation energy transfer between  $Er^{3+}$  and  $Yb^{3+}$  ions. Conditions are identified under which the medium becomes bleached at the pumping radiation frequency: this is especially pronounced under conditions of strong backward energy transfer from the  $Er^{3+}$  to the  $Yb^{3+}$  ions, which is typical of glasses in which the intra-center relaxation rate of  $Er^{3+}$  ions is small. A model that assumes a linear relationship between the inter-ion transfer rate and the population of the fundamental acceptor state describes well the accumulation of inverse population in Yb-Er glasses. References 17: 10 Russian, 7 Western. Figures 3.  
[397-6900/12955]

UDC 532.525:539.104

## EFFECT OF PULSE DEPENDENT DISCHARGE ON RELAXING GAS FLOW

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 17 Apr 84), pp 540-545

LEVIN, V. A., NETESOV, V. V. AND Yu. V. TUNIK, Institute of Mechanics, Moscow State University imeni M. G. Lomonosov

[Abstract] A dependent-discharge  $CO_2$  electroionization laser is examined. A system of gas dynamic equations is augmented with vibrational kinetic equations (equations that allow for the interaction of the discharge with a gas stream) and an equation for the radiation intensity. The influence of gas dynamic processes on the characteristics of an electric discharge  $CO_2$  laser is examined on the basis of a one-dimensional model. The influence of gas dynamic perturbations occurring in the discharge chamber, and of heating of the medium, on the output power in the pulsed and pulse-periodic modes is investigated analytically. The optimum pulse repetition frequency is found for different energy contributions to the discharge. References 18: 14 Russian, 4 Western. Figures 4.  
[397-6900/12955]

**"IGLAN-3" MULTIBEAM CW GAS-DISCHARGE CO<sub>2</sub> LASER**

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 18 Apr 84), pp 553-562

KOZLOV, G. I. AND V. A. KUZNETSOV, Institute of Problems of Mechanics, USSR Academy of Sciences

[Abstract] The "IGLAN-3" multibeam laser -- a high-power multibeam gas discharge diffusion-cooled system -- is examined in detail. The optimum operating conditions are determined by changing sequentially the governing parameters -- the composition of the laser mixture, the gas pressure, and the discharge characteristics. The optical properties of the active medium are investigated. The divergence of the output radiation and the intensity distribution in the focused beam are measured. Although the intensity is somewhat irregular over the cross-section of the beam since the different channels operate slightly differently, the intensity distribution is found to be sufficient for technological heat-treatment, surface doping, melting, and other processes. References 13: 5 Russian, 8 Western. Figures 6.  
[397-6900/12955]

**COMPETITION OF ORTHOGONALLY POLARIZED MODES IN TWO-MODE CO<sub>2</sub> LASER**

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 20 Apr 84), pp 571-575

YERMACHENKO, V. M., PETROVSKIY, V. N., PROTSENKO, Ye. D., RURUKIN, A. N. AND SHANANIN, R. A., Moscow Engineering-Physics Institute

[Abstract] The interaction of two linearly and orthogonally polarized modes is investigated experimentally and theoretically in a CO<sub>2</sub> laser employing separate vibrational-rotational transition. The influence of the mode field characteristics of the phase-anisotropic cavity on inter-mode competition is examined, as well as their relationship to the pressure of the active medium and the amount by which the gain exceeds the threshold. Stable two-mode lasing is obtained for distances between modes of 0.3-70 MHz, with the maximum region around 80 MHz. Strong inter-mode interaction is observed even with a longitudinal offset between the generated modes, making it impossible to achieve large double-mode lasing regions. Transverse mode separation is found to play a determined role in reducing mode interactions. References 8: 7 Russian, 1 Western. Figures 5.  
[397-6900/12955]



## STOCHASTICITY AND REGULAR PULSATIONS IN Q-SWITCHED LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 6 June 84), pp 614-616

VASNESTOV, M. V., PESHKO, I. I. AND SOSKIN, M. S., Institute of Physics,  
Ukrainian SSR Academy of Sciences

[Abstract] A method is described for obtaining periodic pulses in an active Q-switched laser by linear conversion of the amplitude-time structure of the noise signal in a three-mirror cavity. An experimental set-up is described that incorporates an industrial LTI-PCh laser with mirrors arranged to form a 60-cm cavity. An operating mode is achieved in which the radiation forms chaotic, non-repeating pulsations with period  $T_p$ . The use of an amplifying medium with a broad amplification band (such as neodymium and glass) makes it possible to obtain pulse trains with variable repetition period and carrier frequency. References: 3 Russian. Figures 2.  
[397-6900/12955]

## INVESTIGATION OF ELECTROIONIZATION PULSED CARBON DIOXIDE ISOTOPE OUTPUT CHARACTERISTICS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 19 July 84), pp 622-624

BARDAKOVSKIY, S. V., BLADIMIROVA, N. M., SARUBIN, P. V., LYAKISHEV, V. G.,  
KHOLODILOV, A. A., TSAREV, V. M. AND CHEBURKIN, N. V.

[Abstract] The efficiency and spectral composition of radiation from a pulsed electroionization laser operating at atmospheric pressure in which the working mixture contains the carbon dioxide isotopes  $^{12}\text{C}^{16}\text{O}_2$ ,  $^{13}\text{C}^{16}\text{O}_2$ , and  $^{12}\text{C}^{18}\text{O}_2$  are investigated experimentally. Lasing with  $^{13}\text{C}^{16}\text{O}_2$  occurs simultaneously on five vibrational-rotational transitions, while with  $^{12}\text{C}^{18}\text{O}_2$  it occurs on one transition. The operating efficiency is close to that of an ordinary  $^{12}\text{C}^{16}\text{O}_2$  laser, with the energy contribution determined by the presence of impurities in the working mixture. References 13: 11 Russian, 2 Western. Figures 3.  
[397-6900/12955]

HYSTERESIS EFFECTS IN  $\text{Ar}^+$  LASER WITH NONLINEAR ABSORBER IN THE CAVITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 25 Jul 84), pp 625-627

GAFUROV, Kh. G. and D. P. KRINDACH, Physical-Technical Institute imeni  
U. V. Arovo, Tadzhik SSR Academy of Sciences

[Abstract] The nature of hysteresis phenomena in the lasing power near the threshold is discussed for a passive mode-locked  $\text{Ar}^+$  laser. The system in question employs a GL-301 gas discharge tube as the amplifying element, and a tube with a 15-cm discharge length as the absorbing element. Hysteresis is found to be associated essentially with those active medium saturated processes that govern passive mode locking. The discussions hold true for any passive mode-locked laser with the same characteristic time relationship as the  $\text{Ar}^+$  laser. References 7: 1 Russian, 6 Western. Figures 2.  
[397-6900/12955]

## A MATHEMATICAL MODEL OF THE RADIATION OF A MULTICHANNEL LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 27 Jul 84), pp. 627-630

CHEREPENIN, N. D., Kazan State University imeni V. I. Ulyanov-Lenin

[Abstract] A mathematical model for multichannel laser radiation is described that can be used to investigate the beam divergence. The multichannel laser is interpreted as a system of several identical sources whose field distributions differ in phase. It is found that the angular distribution of radiation intensity and energy corresponds on the average to that of a single isolated source. As the solid angle  $\Omega$  increases, the energy flux fluctuations disappear gradually, and the energy becomes constant. The angular divergence of the radiation is investigated using a pair of ideal non-coherent radiators with elliptical or rectangular apertures. References: 4 Russian. Figures 3.  
[397-6900/12955]

UDC 621.373.826.038.823

LASING OF XeCl, XeF AND KrF EXCIMER MOLECULES IN TWO-COMPONENT MIXTURES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 10 Jul 84), pp 643-644

ZUBRILIN, N. G., MILANICH, A. I., CHERNOMORETS, M. P. AND YURCHUK, S. V.,  
Kiev State University imeni T. G. Shevchenko

[Abstract] Fast-discharge lasing in dual-component mixtures is achieved in a system with a 30-cm chamber and external cavity. Lasing is obtained on XeCl, XeF, and KrF molecules in mixtures with no buffer gas. The investigation of lasing and dual-component mixtures excited by a fast discharge makes it possible to establish the parameters of the processes which lead to the formation of excimer molecules, and to understand better the role of the buffer gas in the active medium of excimer lasers. References: 5 Western. Figures 2.

[397-6900/12955]

UDC 621.378.325

LASER EMPLOYING WAVEFRONT CONVERTING MIRROR WITH Q-SWITCHING BY STIMULATED BRILLOUIN BACKSCATTERING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 17 July 84), pp 655-656

ARAKELYAN, V. S. AND RYLOV, G. Ye., Institute of Physical Research, Armenian SSR Academy of Sciences

[Abstract] The spectral, temporal, and spatial characteristics of an Nd:Yag laser incorporating a Brillouin conjugating mirror in the stable region of the cavity are investigated. The use of stimulated Brillouin backscattering is shown to be effective for cavity Q-switching, and provides more output power than electrooptical modulators or bleaching filters. References 9: 6 Russian, 3 Western. Figures 2.

[397-6900/12955]

HIGH-POWER CO<sub>2</sub> ELECTRIC DISCHARGE LASER WITH EASILY IONIZED SUBSTANCES ADDED

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 24 April 84), pp 5-9

APOLLONOV, V. V., VASKOVSKIY, YU. M., ZHAVORONKOV, M. I., PROKHOROV, A. M., ROVINSKIY, R. Ye., ROGALIN, V. Ye., USTINOV, N. D., FIRSOV, K. N., TSENINA, I. S. AND YAMSHCHIKOV, V. A., Institute of General Physics, USSR Academy of Sciences

[Abstract] Optimization of the parameters of a transverse-discharge CO<sub>2</sub> laser as described in a previous study by the authors is investigated. The output characteristics of the laser are optimized by investigating the radiated energy as a function of the length of the active medium as well as the coefficient of reflection of the exit mirror. It is found that by selecting the easily ionized substances and pumping mode properly, and optimizing the cavity, it is possible to obtain efficiencies and unit energy yields from an externally-driven CO<sub>2</sub> laser that are as good as those of corresponding electroionization systems. The laser used in the study employs an extremely compact electrode design, and requires no low-inductance capacitors in the pumping circuit. Specific output energy of 51 J/l and electric energy-to-light conversion efficiency of 22% are achieved. Figures 3; references 11: 7 Russian, 4 Western.

[274-6900/12955]

## INFLUENCE OF IR LASER PULSE DURATION AND SHAPE ON DYNAMICS OF COHERENT EXCITATION IN VIBRATIONAL MOLECULAR MODE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 16 Feb 84), pp 29-40

PARAMONOV, G. K. AND SAVVA, V. A., Institute of Physics, Belorussian SSR Academy of Sciences

[Abstract] This study presents a theoretical investigation of the dynamics of coherent excitation in the vibrational mode to find the most effective excitation modes and to identify local populations at individual vibrational levels. The vibrational mode is modeled by a harmonic oscillator with exciting laser radiation de-tuned (from resonance) by an amount on the order of the anharmonicity constant. The model allows various excitation modes to be investigated analytically, so that the initial parameters of the laser pulses can then be selected properly for numerical analysis of the dynamics of a more realistic model -- a nonlinear quantum oscillator. The dynamics and mode excitation efficiency are investigated on the basis of analytical and numerical solutions to the Schroedinger equation for the probability

amplitudes in resonant approximation that are derived in the study. The best excitation efficiency is achieved when resonant laser pulses are used. These pulses are determined by vibrational anharmonicity and fall into the picosecond region. Figures 6; references 32: 18 Russian, 14 Western.  
[274-6900/12955]

UDC 621.373.826.038.824

#### GENERATION OF PICOSECOND PULSES IN MONOPULSE-PUMPED DYE LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 16 Feb 84), pp 41-47

YEGOROV, K. D., PETNIKOVA, V. M., PLESHANOV, S. A. AND SHUVALOV, V. V.,  
Moscow State University imeni M. V. Lomonosov

[Abstract] Stimulated emission of radiation by thin cavity cuvettes and laser systems consisting of such a cuvette and an external dispersion cavity is investigated. Four different stages are identified in the development of stimulated emission: the formation of inverse population, linear amplification of spontaneous noise, nonlinear amplification with the formation of a time pulse envelope, and decay of the residual inverse population. An experimental setup employing a YAG passive Q-locked laser with a repetition frequency less than 3 Hz is described. The dynamics of stimulated emission was shown to agree exactly with the results of the numerical experiment. Spectrally limited pulses 3.5 picoseconds long are produced. Figures 5, references 10: 5 Russian, 5 Western.  
[274-6900/12955]

UDC 621.373.826.038.823

#### BARIUM-VAPOR PULSED LASER IN SELF-HEATING MODE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 13 March 84), pp 68-73

ISAYEV, A. A. AND LEMMERMAN, G. Yu., Physics Institute imeni P. N. Lebedev,  
USSR Academy of Sciences

[Abstract] A barium-vapor laser in the self-heating mode is investigated in order to ascertain the effect of such excitation system parameters as the power supply, working capacitance, rectifier voltage, etc., on output lasing characteristics. The primary emphasis is on the electrical characteristics of the excitation pulse. A laser with a corundum discharge tube 20 mm in diameter and 50 cm long is investigated. The lasing efficiency, or the calculated energy contribution to the active impedance of the loop, is found to exceed the actual lasing efficiency by approximately a factor of 3. Lasing

and pulse characteristics are investigated as a function of the working capacitance for a fixed pulse repetition frequency. It is found that the average lasing power increases with the peak pumping power and with the amplitude of the current. The abrupt drop in lasing efficiency noted as the working capacitance increases may be associated with an increase in the excitation pulse duration and the divergence between that and the lasing duration that occurs. Figures 5, tables 1, references: 6 Russian.  
[274-6900/12955]

UDC 621.373.826.038.823

#### SPATIAL, TEMPORAL AND ENERGY CHARACTERISTICS OF COPPER-VAPOR LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 14 March 84), pp 74-79

BELYAYEV, V. P., ZUBOV, V. V., ISAYEV, A. A., LYABIN, N. A., SOBOLYEV, YU. F.  
CHURISIN, A. D., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The spatial, temporal and energy characteristics of the radiation from a copper-vapor laser based on a GL-201 element are investigated. An active element 1220 mm long with exit pupils at an angle of  $85 \pm 1^\circ$  to the optical axis is employed. The operation of the active element is examined in the superluminance mode, and with stable and unstable cavities. The use of a similar active element as an amplifier in conjunction with a spatial selector for the diffraction beam after it leaves the master oscillator made it possible to increase the average lasing power in the diffraction beam to 30-35 W. Figures 6, tables 1, references 6: 5 Russian, 1 Western.  
[274-6900/12955]

UDC 621.375.826.038.823

#### AMPLIFICATION OF PULSED RADIATION IN REGENERATIVE TEA CO<sub>2</sub> LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 28 March 84), pp. 99-103

PLATONENKO, V. T. and TARANUKHIN, V. D., Moscow State University imeni M. V. Lomonosov

[Abstract] The characteristics of a regenerative electric discharge TEA CO<sub>2</sub> laser into which pulsed single-mode radiation is injected are investigated numerically. It is found possible to achieve lasing with single-mode radiation without stabilizing the parameters either of the amplifier or the master oscillator. Figures 6, references 9: 3 Russian, 6 Western.  
[274-6900/12955]

# ENERGY AND SPECTRAL CHARACTERISTICS OF CW ELECTROIONIZATION CO<sub>2</sub> LASER WITH CRYOGENICALLY COOLED WORKING MIXTURE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 25 April 84), pp 140-143

AVERIN, A. P., BOSOV, N. G., PLOTOV, Ye. P., DANILYSHEV, V. A., KARPOV, G. N., KERIMOV, O. M., KRASOVSKIY, V. M., MALYSH, M. M., SAZHINA, N. N., SOROKA, A. M., TSEPELYEV, V. Ye., USTINOV, N. D. AND CHEBURKIN, N. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The energy and spectral characteristics of an industrial CW electroionization CO<sub>2</sub> laser are investigated at temperature of 220-260 K. The experiments indicate that cooling the laser mixture to approximately 200 K is a very effective means for improving the lasing efficiency of CO<sub>2</sub> electroionization lasers, which makes it possible to increase the power of laser devices significantly without increasing their dimensions. Figures 3, references: 15 Russian.

[274-6900/12955]

# COMPARATIVE ANALYSIS OF OPTICALLY AND ELECTRONICALLY PUMPED BROADBAND EXCIMER LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 14 March 84), pp 180-183

MAROVSKI, G., KANAYEV, A. V., MIKHEYEV, L. D. AND STAVROSKIY, D. B., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The gains, absorption losses and energy characteristics of Kr<sub>2</sub>F\*, Xe<sub>2</sub>Cl\* and XeF\* lasers with electronic and optical pumping are compared. Electron-beam pumping is found to be preferable in terms of gain; however, electron beam pumping produces large induced absorption in the active medium because of the atomic, ion and molecular products that are formed. Optical pumping is found to produce low gain, and requires long active laser length. The energy parameters provided by electron beam pumping are significantly more modest; however, gains of an order of magnitude greater can be achieved, so that lasing is easily cited even in small volumes of active medium. Figures 1, tables 1, references 32: 9 Russian, 23 Western.

[274-6900/12955]

## RELATIVE RESISTANCE OF WORKING MIXTURES OF IODINE PHOTODISSOCIATION LASERS TO DEVELOPMENT OF ENTHALPIC RAMAN SCATTERING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 10 July 84), pp 184-186

KOROLKOV, K. S., NOSACH, O. Yu. AND ORLOV, Ye. P., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A simple, fast experimental method is proposed for finding the relative unsteady gain for working mixtures of random composition. The experiments were conducted on an iodine photodissociation laser pumped by a coaxial xenon lamp. The optical inhomogeneities in the active medium of the laser were recorded interferometrically with and without laser radiation. It is found that the ratio of the measured depths of the troughs in the wave profiles of the inhomogeneities in different working mixtures coincide with the ratio of the unsteady gains for the theoretically calculated enthalpic Raman scattering. The quantitative connection found between the depth of the trough in the inhomogeneity wave and the unsteady gain in enthalpic Raman scattering can be used in the theoretical description of the mechanism underlying the occurrence of the trough and the causes for the stability of its shape. Figures 1, tables 2, references: 6 Russian.  
[274-6900/12955]

## SINGLE-FREQUENCY CW LASING IN INJECTION LASER BASED ON TERRACED HETEROSTRUCTURE WITH EXTERNAL DISPERSION CAVITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12 No 1, Jan 85  
(manuscript received 19 March 84), pp 162-164

BOGATOV, A. P., GOLDOBIN, I. C., YELISEYEV, P. G., OKHOTNIKOV, O. G., PAK, G. T., RAKHVALSKIY, M. P., FAYNBOYM, Ye. G. AND KHAYRETDINOV, K. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] A single-frequency laser with an external dispersion cavity is investigated that employs a laser diode with a "terraced" active region as the active element. Output power of 35 mW is achieved, which is twice the highest power achieved previously in external-cavity lasers. It is found that transverse instability of the field in the active region of the laser causes single-frequency lasing to cease when the output power is increased. Output power can be increased further in the single-frequency mode by improving the active element in order to stabilize the lateral configuration. Figures 3, references 11: 8 Russian, 3 Western.  
[274-6900/12955]



## WAVELENGTH SWITCHING IN COPPER-VAPOR LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 12 May 84), pp 196-197

ZENCHENKO, S. A., IVANOV, V. I., MALEVICH, I. A. AND SHULEKIN, S. F.,  
Scientific Research Institute for Physical Problems imeni A. N. Sevchenko,  
Belorussian State University imeni V. I. Lenin

[Abstract] This study presents the preliminary results of an investigation of the emission modes of copper vapor lasers employing an intra-cavity anisotropic filter consisting of polarization filters with parallel transmission axes that are separated by crystalline quartz plates set at the Brewster angle. The use of this birefringent filter for switching the lasing wavelength is described. It is found that the use of a simple birefringent filter makes it possible to switch wavelengths, which expands the area of application of copper vapor lasers. Eliminating the exit polarization filter can also make it possible to control the polarization characteristics of the radiation. Figures 1, references 3: 1 Russian, 2 Western.  
[274-6900/12955]

## INFLUENCE OF RADIATION SPECTRAL COMPOSITION ON GAIN IN NEODYMIUM GLASS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 18 April 84), pp 217-219

DANILOV, A. Ye., ORLOV, V. V., SAVCHENKO, S. M., SUCHKOV, A. F., FEDOTOV, S. I.  
AND A. L. KHITROV, Physics Institute imeni P. N. Lebedev, USSR Academy of  
Sciences

[Abstract] The amplification efficiency in the saturation mode of nanosecond laser pulses in silicate neodymium glass is investigated as a function of the spectral distribution width of the radiation. The influence of the radiation spectral composition on the output of stored energy was investigated by means of the linear preamplification stages of a Del'fin-1 system. It is shown experimentally that broadening of the radiation spectrum from 7 to 10.6 nm in an amplifier with a GLS-1 glass active element increases the gain by 25% and improves the divergence by 30%. Estimates indicate that the Del'fin-1 output energy can be at least doubled, with unchanged divergence, by generating radiation with spectrum width of 10-20 nm in the linear preamplification stages. Figures 3, references: 4 Russian.  
[274-6900/12955]

TUNABLE YAG:Nd<sup>3+</sup> LASER WITH GLANCING DIFFRACTION GRATING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 25 April 84), pp 219-220

GLADKOV, S. M. AND KUZNETSOV, V. I., Moscow State University imeni N. V. Lomonosov

[Abstract] This study describes the use of a glancing diffraction grating in a YAG:Nd<sup>3+</sup> laser to provide continuous frequency tuning within the limits of the luminescence line of the active element. The low gain of the garnet crystal is overcome by employing a T-cavity so that each pass of the radiation through the cavity entails two passes through the active element, which increases the effective gain significantly. The laser can be employed in numerous systems requiring frequency tuning over short ranges, where it can be more convenient than systems employing dye or F-center lasers. The use of phosphate glass active elements allows this laser to be tuned over a spectral band more than 100 cm<sup>-1</sup> wide; more careful selection of diffraction gradings makes it possible to increase lasing energy significantly. Figures 2, references: 2 Russian, 2 Western.  
[274-6900/12955]

H<sub>2</sub>/F<sub>2</sub> CHEMICAL LASER INITIATED BY EXCIMER FLASHLAMP

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 24 April 84), pp. 220-223

GORDON, Ye. V., MATYUSHENKO, V. I., PAVLENKO, V. S. AND SIZOV, V. D.,  
Institute of Chemical Physics, USSR Academy of Sciences

[Abstract] This study presents the results of an investigation of a H<sub>2</sub>/F<sub>2</sub> chemical laser built by the authors that is initiated by an excimer flashlamp. The lasing energy of the HF laser and the UV luminescence of the excimer flashlamp are investigated as a function of the composition and pressure of the mixture in the lamp chamber and the charge voltage of the power supply. Suppression of the superluminescence of the flashlamp, which is necessary for the chemical laser to work, is discussed. The technical efficiency of the flashlamp is estimated at approximately 5%, which is 10 times greater than that of the excimer laser on which it is based. The possibility of increasing the efficiency of chemical lasers initiated by achieving a mode in which the formation of the excimer molecules and vibrational excited HF molecules coincides in space is discussed. Figures 2, references 12: 9 Russian, 3 Western.  
[274-6900/12955]

YAG:Er<sup>3+</sup> CROSS-RELAXATION LASER

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 25 Jul 84)

LOBACHEV, VLADIMIR ANDREYEVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] The ion-ion transfer of excitation energy (cross-relaxation) in (Y, Er)<sub>3</sub>Al<sub>5</sub>O<sub>12</sub> crystals is investigated experimentally. The influence of cross-relaxation on inversion formation and the lasing of a YAG:Er<sup>3+</sup> laser is investigated. The excitation conditions and modes for a YAG:Er<sup>3+</sup> laser are selected, and the lasing characteristics are studied. The mechanism underlying the formation of inverse population of the <sup>4</sup>I<sub>11/2</sub> - <sup>4</sup>I<sub>13/2</sub> ion of Er<sup>3+</sup> in yttrium-aluminum garnet crystals is explained. Relaxation of the excitation energy from the S<sub>3/2</sub> level is found to be governed by a cross-relaxation mechanism. Kinetic equations composed to allow for cross-relaxation processes are used to analyze laser operation. A YAG:Er<sup>3+</sup> cross-relaxation laser with good energy characteristics with free lasing efficiency of about 1.5% and differential efficiency of about 3%, producing output energy of up to 6 J, is described. References 6: 5 Russian, 1 Western. [324-6900/12955]

## SPECTRAL CHARACTERISTICS AND SELECTIVITY OF VIBRATIONAL EXCITATION ON MOLECULES IN IR LASER FIELD UNDER CONDITIONS OF GAS DYNAMIC COOLING

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 26 Nov 84)

NIKIFOROV, SERGEY MIKHAYLOVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] The basic physical processes governing the formation of the resonance structure in the dissociation spectrum of polyatomic molecules are identified. The structure of the spectral behavior of the dissociation yield is investigated, and the rate of collisional transfer of vibrational excitation between molecules with different isotopic composition is determined in order to realize optimum dissociation conditions of polyatomic molecules with good selectivity and efficiency. A high pressure continuously tunable CO<sub>2</sub> laser incorporating a gas dynamic molecule cooling system is described. It is shown possible to control the dissociation spectrum by selecting their parameters of the exciting fields. Molecular dissociation with three-frequency laser excitation is proposed and realized. The structure of the third-harmonic lasing spectrum is detected and investigated in SF<sub>6</sub> and O<sub>3</sub>O<sub>6</sub>. References 7 Russian.

## NUCLEAR PHYSICS

UDC 535.312/313.621.039.6

### PARAMETERS OF FOCUSING OPTICS OF LASER THERMONUCLEAR REACTOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 11 July 84), pp 584-593

BASOV, N. G., BELOUSOV, N. I., VERGUNOVA, G. A., GRISHYNIN, P. A., DANILOV, A. Ye., LEBO, I. G., ROZANOV, B. B., SKLIZKOV, V. I., SUBBOTIN, V. I., FEDOTOV, S. I., AND KHARITONOV, V. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Physical constraints are determined for the basic parameters of targets for laser thermonuclear reactors. The reaction product energy absorbed by the focusing optics is found to exceed significantly the absorbed laser pulse energy. The x-radiation spectrum of the target is calculated and used to find the minimum distances from the center of the chamber to the optical system. The divergence of high-power laser radiation and the small target dimensions make focusing difficult. The use of exit mirrors in the focusing system is found to be more promising than lenses. The use of IR lasers, pulses that are not strongly shaped over time, and thermonuclear targets with small energy gain -- typical of hybrid reactors -- makes it easier to design the focusing optics. References 25: 12 Russian, 13 Western. Figures 5.

[397-6900/12955]

UDC 539.184.27

### NONEQUILIBRIUM EFFECTS AND STRUCTURE OF X-RAY LINES IN TOKAMAK PLASMA

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 3 May 84), pp 438-492

GONTIS, V. G. AND LISITSA, V. S., Institute of Atomic Energy imeni I. V. Kurchatov, Institute of Physics, Lithuanian SSR Academy of Sciences

[Abstract] The sensitivity of X-ray spectra to a number of typical non-equilibrium effects occurring in modern Tokamaks is examined. Experimental data

from the T-10 and ST Tokamaks are cited to illustrate the degree of deviation from coronal equilibrium. The analysis exploits recent atomic data for radiation and autoionization line widths; standard semiempirical formulas are used to calculate the rates of collision processes. Ion diffusion and impurity distribution by degrees of ionization are investigated. The sensitivity of  $K_{\alpha}$  radiation to electron nonequilibrium and ion charge exchange is examined. References 22: 10 Russian, 12 Western. Figures 7.  
[405-6900/12955]

UDC 535.375

STUDY OF THE KINETICS OF MOLECULAR NITROGEN BY THE METHOD OF WIDE-BAND COHERENT ANTISTOKES SCATTERING OF LIGHT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 281, No 6, Apr 85  
(manuscript received 23 Jan 85) pp 1355-1359

DEVYATOV, A. A., DOLENKO, S. A., AND ROY, N. N., Scientific-Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov

[Abstract] Molecular nitrogen excited by electron impact in a plasma, formed by a pulsed self-sustaining discharge with ultraviolet preionization, was studied with the use of wide-band coherent antistokes scattering of light (CASL). The CASL spectrum at the end of the discharge current pulse was obtained; the vibrational distribution function was determined at times immediately following the discharge and 2.8  $\mu$ sec and 1.45 msec later; and, the populations of levels with  $v = 0, 1, 2, 3$ , and 4 were measured as a function of time. The gas pressure in the discharge was 60 Torr, the gas interelectrode length was 1 cm, the duration of the discharge current pulse at half height was 300 nsec, and the specific energy input into the discharge was 1 J/cm<sup>3</sup>. The CASL spectrometer was based on a YAG:Nd<sup>3+</sup> laser operating in the TEM<sub>00</sub> mode. The master oscillator was frequency doubled and used as a laser pump. The unconverted part of the radiation with  $\lambda = 1.06 \mu$ m was filtered out of the radiation at the second harmonic, its frequency was doubled again, and it was then used to pump an organic laser. The active medium in the organic laser was a solution of 6-aminophenolene in ethanol. Wide-band pumping radiation was obtained at the Stokes frequency, corresponding to the difference between the laser pump frequency and the Stokes frequency tuned to the region of main combination resonance for nitrogen  $\Omega_{01}/2\pi c = 2330 \text{ cm}^{-1}$ . A multi-channel spectrum analyzer was used to record the CASL spectrum. The overall resolution of the system was  $= 1.9 \text{ cm}^{-1}$ . This spectrometer obtained high-quality spectra for molecular nitrogen from a single firing of the laser. The limiting sensitivity of the spectrometer in detecting nitrogen molecules at ground state was equal to about  $10^{17}$  molecules/cm<sup>3</sup>. Figures 3; references 5: 4 Russian; 1 Western.  
[406-9638/12955]

# POSSIBILITY FOR OPTIMIZING THERMAL INTERACTION IN A MOVING FOCUSING MEDIUM BY AMPLITUDE-PHASE CORRECTION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 22 Feb 84), pp 54-59

VDOVIN, V. A., SOROKIN, Yu. M. AND DAVYDOV, V. I., Gorkiy State University

[Abstract] An experimental investigation of the thermal interaction of light beams scanning along second-order curves in the plane perpendicular to the beam axis is described. Elliptical as well as parabolic scanning trajectories were employed; and scanning rate, laser pulse repetition frequency and exposure time were selected to record the time-averaged intensity profile of the scanning beam at the cuvette output. It is found that a parabolic scanning trajectory that is "open" against the wind provides near-optimum intensity. A complex amplitude-phase adaptive system is investigated numerically, showing that when the nonlinearity is sufficient the system provides a significant advantage over a corresponding phase system for suboptimal control. Figures 6, references 10: 9 Russian, 1 Western.  
[274-6900/12955]

UDC 535.375.54; 535.323; 548.75; 621.375.826

# NONLINEAR OPTICAL SPECTROSCOPY OF PHONON POLARITONS

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 6 Jun 84)

POLIVANOV, YURIY NIKOLAYEVICH, Institute of General Physics, USSR Academy of Sciences.

[Abstract] The physical mechanisms, singularities, and general principles of Raman scattering, coherent anti-Stokes scattering, and two-photon combination scattering of light on polaritons are established and investigated experimentally. New spectroscopic methods are developed based on these processes for solving problems in quantum electronics and solid state physics. It is found that two-photon scattering can be used to investigate polaritons of the upper dispersion branches in optically isotropic media. The characteristics and regularities of the scattering spectra of uniaxial and bi-axial polyatomic crystals are interpreted. The singularities occurring in the spectral of Raman scattered light on polaritons are studied experimentally. The interference of direct four-phonon and cascaded three-phonon processes in the anti-Stokes spectra of crystals without centers of symmetry is detected. References 48 Russian.  
[324-6900/12955]

# DIAGNOSIS OF POPULATIONS AND RELAXATION PROCESSES OF VIBRATIONAL AND ROTATIONAL STATES OF MOLECULES IN GASES BY COHERENT ANTI-STOKES SCATTERING SPECTROSCOPY

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 21 Aug 84)

FABELINSKIY, VIKTOR IMMANUILOVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] Coherent anti-Stokes scattering spectroscopy is employed to investigate spectral line contours and to measure the rotational relaxation times in molecular gases by measuring line widths as a function of pressure. The molecule distribution functions are investigated at vibrational and rotational states in non-equilibrium and equilibrium excited gas systems; the influence of the gas temperature and pressure on the form of the coherent anti-Stokes spectra is studied. The velocity constants of the intra-mode resonant exchange of vibrational energy in gases are measured by the dynamics of the line intensities in the Stokes spectra. The gases in question, acetylene and nitrogen, are investigated by means of a pulse spectrometer with resolution of  $0.2 \text{ cm}^{-1}$  and sensitivity of approximately  $10^{14} \text{ molecules/cm}^3$ . References 14 Russian. [324-6900/12955]

# RESONANT FREQUENCIES OF GATES IN SPATIALLY DISPERSED OPTICAL MEDIA

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 281, No 5, Apr 85 (manuscript received 13 July 84), pp 1085-1088

KARASEV, M. V., ACADEMICIAN V. P. MASLOV, AND A. V. PERESKOKOV, Moscow Institute of Electronic Machine Building

[Abstract] A mathematical model of an optical gate based on the spatial dispersion effect is investigated. This dispersion occurs in media in which the permittivity is a non-local function of the field intensity. The self-focusing effect causes a self-consistent waveguide channel to form in the medium, whose characteristic frequencies determine the locations of the jumps in the throughput characteristics of the gate. Formulas are derived which determine explicitly the asymptote of the series of eigenfrequencies of the self-consistent waveguide and intensity, as well as permittivity. Consequently, the logic gate based on the nonlinear medium in question can be switched by changing the intensity, as well as by changing the initial permittivity. A model of a gate exploiting both of these mechanisms is suggested. References 7: 3 Russian, 4 Western [396-6900/12955]



## NONLINEAR IONIZATION OF MULTI-ELECTRON ATOMS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 3, Mar 85, pp 471-478

DELONE, N. B., Institute of General Physics, USSR Academy of Sciences

[Abstract] This review summarizes research on nonlinear ionization of atoms: single-electron multiphoton ionization of alkali-earth atoms and lanthanides, and the formation of doubly-charged ions during nonlinear ionization of atoms with two external electrons. The possibility of finding coherent radiation sources in the far ultraviolet region of the spectrum is discussed.

References 32: 22 Russian, 9 Western. Figures 4.

[382-6900/12955]

## INTENSE BEAMS OF COLD ATOMS FOR LASER SPECTROSCOPY

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49, No 3, Mar 85, pp 479-486

BALYKIN, V. I., LETOKHOV, V. C., MINOGIN, V. G. AND SIDOROV, A. I., Institute of Spectroscopy, USSR Academy of Sciences

[Abstract] Longitudinal cooling of beams of atoms by extended interaction with strong laser radiation is examined. An experimental set-up is described in which a narrow beam of atoms is irradiated by a counter-propagating light beam in resonance with the  $3^2S_{1/2}-3^2P_{3/2}$  transition of the sodium atom. The longitudinal velocity distribution is recorded by a second laser probe beam which intersects the atom beam at a slight angle at the end of the zone of interaction with the strong beam. Optimum conditions are defined for the configuration of the laser beam, and for the time and length of interaction, to ensure a low effective atom beam temperature with high intensity. Transverse cooling of atom beams by radiation collimation is described. It is estimated that the atom density can be increased significantly, and atom beams with the smallest possible transverse temperature can be obtained, by using a large collimator or a retarded atom beam. The ability to obtain intense atom beams at low temperatures makes it possible to use cold atoms in precision spectroscopy. References 10: 7 Russian, 3 Western. Figures 8.

[382-6900/12955]

## DIFFRACTION EFFICIENCY OF PHASE HOLOGRAMS WITH SUPERIMPOSED EXPOSURES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 16 Mar 84), pp 1-3

SHEVTSOV, M. K.

[Abstract] Variation of the diffraction efficiency of three-dimensional reflecting phase holograms by superimposing exposures at different wavelengths is investigated as a function of the relationship between the exposures, the total exposure, and the dynamic range of the medium. A loss-free recording medium with index of refraction varying linearly with the exposure is analyzed. Holograms are recorded with exposures superimposed at any two of three wavelengths emitted by argon or helium-neon lasers. PE-2 photoemulsion (synthesized in the laboratory) provides good diffraction efficiency at all wavelengths. It is found that diffraction efficiency of phase holograms is maintained better than that of amplitude holograms when two exposures are superimposed. The proposed method for investigating superimposed two-color holograms can also be used for three or more superimposed wavelengths on the same recording medium. References 12: 10 Russian, 2 Western. Figures 3.  
[383-6900/12955]

## DIFFRACTION EFFICIENCY OF HOLOGRAPHIC GRATINGS WITH SYMMETRICAL PROFILES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 6 April 84), pp 4-6

DMITRIEVA, L. A., GOLUBENKO, I. V. AND SAVITSKIN, G. M.

[Abstract] The diffraction properties of holographic reflecting diffraction gratings are examined. An approximation for infinite conductivity is used based on a sufficiently accurate and simple numerical method which uses integral equations to solve problems of electromagnetic waveguide splitting by a reflecting grating of arbitrary profile. The optimum channel depth for different profiles is analyzed. The preferable profile for different fixed channel depth and the preferable symmetrical profile for obtaining the best efficiency are studied. The diffraction efficiency is examined as a function of the light wavelength, with one of the diffraction harmonics propagating in the opposite direction of the incident light. The best diffraction efficiency is obtained by using a grating profile with elongated peaks, smooth bottoms, and channel depth not exceeding 0.4. Profiles with smooth peaks are found to be superior to pointed peaks for  $h/d=0.2$ . References 10: 2 Russian, 8 Western. Figures 4.  
[383-6900/12955]

## DETERMINATION OF OPTICAL INHOMOGENEITY OF CYLINDRICAL BODIES BY LIGHT BEAM DEFLECTION

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(Manuscript received 14 Mar 84), pp 7-9

ABEN, KH. K., IDNURM, S. I., IOZEPSON, Yu. I., KAPLAN, M. S. AND MALINOVSKAYA, S. A.

[Abstract] A simple method is examined for studying the optical inhomogeneity of cylindrical bodies based on measuring the deflection of a laser beam. The radial distribution and axial gradient of the index of refraction are found. A method is proposed for interpreting experimental data when a caustic appears. The concepts of isotropic (scalar) and anisotropic (tensor) optical inhomogeneities is introduced in order to distinguish between optical inhomogeneity with and without birefringence. The optical inhomogeneity of a polymethylmethacrylate cylinder is investigated. References 11: 9 Russian, 2 Western. Figures 4.  
[383-6900/12955]

## OPTIMIZATION FUNCTIONS AND PARAMETERS OF A SYSTEM OF FLAT MIRRORS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 1, Jan 85  
(manuscript received 26 Apr 84), pp 26-27

SIVTSOV, G. P.

[Abstract] The optimized functions and optimization parameters are described for a system of flat reflecting surfaces. The optimized functions of the system of mirrors are the quantities characterizing the geometric properties of the image, and the functions that enter into a system of equations cited in a different study. The parameters of the system of mirrors are divided into internal (constructive), which determine the relative positioning of its reflecting surfaces; and external, which determine the position of the system of mirrors with respect to the other parts of the optical device. Selection of parameters to reduce the number of optimized functions, and thus to make the optimization process easier, is described. References: 6 Russian.  
[383-6900/12955]

## SPATIAL COHERENCE OF OPTICAL FIELDS IN LONGITUDINALLY INHOMOGENEOUS MEDIA WITH SQUARE-LAW INDEX OF REFRACTION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85, pp 501-515

KRIVOSHLYKOV, S. G.; PETROV, N. I. AND I. N. SISAKYAN

[Abstract] The spatial coherence of optical fields propagating in weakly inhomogeneous media with a square-law index of refraction and random longitudinal inhomogeneity is examined. The coherence of fields in weakly inhomogeneous gradient media is examined. Longitudinally inhomogeneous media with square-law and parabolic profiles are analyzed. Analytical expressions are derived for the fields' spatial coherence parameters in such media. The findings can be used to determine waveguide medium parameters experimentally. The results are also useful in investigating the mode noise that is associated with interference between modes in waveguides. References 26: 16 Russian, 10 Western. Figures 4.

[397-6900/12955]

## ENHANCING EFFICIENCY OF ATOM IONIZATION BY PULSED PERIODIC LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85 (manuscript received 22 May 84), pp 611-614

ANDREEV, S. V., MINSHIN, V. I. AND SEKATSKIY, S. K. Institute of Spectroscopy, USSR Academy of Sciences

[Abstract] The possibility is investigated of improving particle trapping efficiency by laser resonant atom photoionization using pulsed laser radiation with a high relative pulse duration. Photoionization of atoms in a closed cavity by laser radiation input to the cavity through a small opening in the wall is examined. Each atom within the cavity either falls within the zone of the laser beam when radiation occurs and is ionized, or it exits through the opening in the cavity wall and is lost. The cavity geometry can be selected to provide capture efficiency exceeding 50% for real radiation parameters (pulse duration up to 15 nsec, and 10 kHz repetition frequency). This method may prove highly effective for ionizing atoms through Rydberg states, in which case the extracting voltage can also serve to ionize atoms already excited to higher Rydberg states. References 8: 6 Russian, 2 Western. Figures 3.

[397-6900/12955]

## TYPES OF OSCILLATIONS IN CAVITY WITH SELF-PUMPED WAVEFRONT CONVERTING MIRROR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 3(153), Mar 85  
(manuscript received 10 July 84), pp 644-647

BELDYUGIN, I. M. AND ZOLOTAREV, M. V.

[Abstract] The transverse mode structure and characteristic frequencies of a cavity containing a self-pumped wavefront converting mirror are investigated. An integral equation is derived for the types of oscillations in such a cavity. The equation belongs to a completely new class of integral equations that has not been used previously in investigating ordinary cavities and externally prompt wavefront conjugation cavities. The properties of cavities incorporating self-pumped wavefront converting mirrors allowed them to be used widely in systems for generating directional optical radiation. References 6: 2 Russian, 4 Western. Figures 1.  
[397-6900/12955]

## POSSIBILITY OF COMPENSATING SMALL-SCALE INHOMOGENEITIES BY A ZERNIKE CELL

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 21 March 84), pp 91-95

SHERSTEBITOV, V. Ye.

[Abstract] A wavefront conjugating mirror based on a Zernicke cell containing no nonlinear elements is examined theoretically. The scheme incorporates a flat mirror and two identical co-focal objectives that implement the Zernike phase contrast method except that the radiation passes twice: once in each direction. The wavefront conjugation distortions are found to be small for the B variation range of interest if the ratio of the characteristic beam dimensions at the input to that of the period of spatial phase fluctuations of the wavefront is greater than 3-3.5. This scheme for correcting small-scale distortions is advantageous in that the coefficient of reflection of the wavefront conjugation mirror is near unity, and is independent of the operating mode laser (continuously repulsed) and of the radiation spectral composition to some extent. Figures 2, references: 11 Russian  
[274-6900/12955]

INFLUENCE OF UNIVERSAL INTRAMOLECULAR INTERACTIONS ON LASER RADIATION FROM  
OXAZINE 17

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 27 March 84), pp 96-98

KOROLKOVA, N. V., KUROKHTIN, N. V. AND UZHINOV, B. M., Moscow State University  
imeni M. V. Lomonosov

[Abstract] This study investigates the influence of intramolecular actions of a universal nature on the luminescence and laser emission of oxazine 17 (a highly efficient working substance that lases in the 600-700 nm region) to identify the conditions under which maximum lasing efficiency can be achieved. Oxazine 17 solutions in polar aprotic solvents are found to provide the best lasing efficiency. The lasing and fluorescence spectral maxima in polar solvents are practically identical; the wavelengths of the former are longer in nonpolar solvents. Figures 3, references: 5 Russian.  
[274-6900/12955]

SHAPE REVERSAL AND RECONSTRUCTION FOR SUPERSHORT LIGHT PULSES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 22 March 84), pp 166-168

TELEGIN, L. S. AND CHIRKIN, A. S., Moscow State University imeni M. V.  
Lomonosov

[Abstract] This study investigates the possibility of finding the shape and duration of supershort laser pulses by the cross-correlation between the initial pulse  $I(t)$  and the temporally reversed pulse  $I(-t)$ . It is shown that the pulse can be reversed in a linear dispersive medium, such as a system consisting of two diffraction gratings. Figures 0, references 9: 4 Russian, 5 Western,  
[274-6900/12955]

## WIND REFRACTION OF PARTIALLY COHERENT LIGHT BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 20 July 84), pp 192-196

ALESHKEVICH, V. A., KOZHORIDZE, G. D., MATVYEV, A. N. AND TERZIYEVA, S. I.,  
Moscow State University imeni M. V. Lomonosov

[Abstract] The spontaneous deviation and defocusing of a partially coherent quasicontinuous Gaussian beam in a medium moving uniformly across the beam are investigated analytically using the approximation of an assigned temperature channel. Formulas are derived for the broadening of the beam and shifting in the wind. The conditions are identified under which the spatial coherence radius becomes smaller in the initial stage of self-interaction.

Figures 2, references 11: 10 Russian, 1 Western.

[274-6900/12955]

## RADIATION FOCUSING BY PRISM RASTER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 1, Jan 85  
(manuscript received 6 June 84 after revision), pp 197-201

DEMENTYEV, A. S. AND DOMARKENE D. P., Institute of Physics, Lithuanian SSR Academy of Sciences

[Abstract] This study describes the focusing properties of a prism raster, which consists of two crossed sets of prisms having the profile of a polyhedron inscribed in a circle. The focusing properties are investigated with the help of the Rayleigh approximation. The transmission function of the raster is derived by approximating the arc of the circle by the corresponding polyhedron. "Hot spots", or intensity spikes, are detected in the radiation focused by the prism raster that result from interference of the coherent radiation that is diffracted on different prisms. This means that the use of prism rasters alone for highly coherent radiation is insufficient for obtaining near-uniform intensity distribution in the focal plane. Figures 3, references 11: 7 Russian, 4 Western.

[274-6900/12955]

## DYNAMIC SELF-FOCUSING OF OPTICAL RADIATION

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA in Russian Vol 26, No 2, Mar-Apr 85 (manuscript received 14 Mar 84), pp 50-55

SUKHORUKOV, A. P. AND TROFIMOV, V. A.

[Abstract] Self-focusing of a beam onto a moving receiver in a dynamic control system is examined. Principles for finding optimum focusing and wave-front inclination are examined. Focusing in a cubic defocusing medium and compensation of thermal defocusing are analyzed. Control effectiveness with compensation performance evaluated by intensity criteria is studied. The influence of constraints on compensation performance in the dynamic control system decreases as the distance to the receiver increases, and increases as the distance to the receiver decreases. References: 4 Russian. [389-6900/12955]

## INVESTIGATION OF FLUORESCENCE KINETICS OF DYES BY PARAMETRIC FREQUENCY CONVERSION

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA in Russian Vol 26, No 2, Mar-Apr 85 (manuscript received 12 Jul 84), pp 63-66

PLESHANOV, S. A. AND SHUVALOV, V. V.

[Abstract] The fluorescence dynamics of solutions of organic dyes is investigated using a set-up based on a passive mode-locked YAG laser. The arrangement and calibration of the experimental system are described in detail. The logarithm of the energy of the converted radiation is measured as a function of the delay between the excitation pulses and the pumping pulses. The electron excitation decay time for RB dye was  $1.8 \pm 0.2$  nsec, and the dipole moment rotation time is  $320 \pm 30$  psec. The method is accurate, and can be used in any spectral band, making it useful in picosecond spectroscopy of condensed media. References 11: 4 Russian, 7 Western. Figures 2. [389-6900]



OPTICAL LOSSES IN IR MATERIALS AND FIBER OPTIC LIGHTGUIDES IN EMISSION REGION OF CO LASER

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 25 Apr 84)

SYSOYEV, Valentin Konstantinovich, Institute of General Physics, USSR Academy of Sciences

[Abstract] A method is developed for spectral measurement of small optical absorption in highly transparent IR materials using calorimetry incorporating a tunable CO laser. The spectral and energy characteristics of a tunable CO laser with various isotope replenishment are investigated. The basic mechanisms underlying optical losses are examined in chalcogenide glasses and thalioium halogen crystals, which are among the most promising materials for use in the emission region of CO lasers. Fiber optic lightguides are fabricated from As-S and As-Se chalcogenide glasses. A prototype fiber optic cable is developed that transmits CO laser radiation at the 5 - 7 W level for medical and technological purposes. References 15 Russian.  
[324-6900/12955]

## PLASMA PHYSICS

### PLASMA-RESONANT DISCHARGE

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 88, No 3, Mar 85 (manuscript received 24 Jul 84), pp 771-780

BRODSKIY, Yu. Ya., GOLUBEV, S. V., ZORIN, V. G. AND FRAYMAN, G. M., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] The characteristics of a plasma-resonant microwave discharge are investigated experimentally and theoretically at pressures between  $3 \cdot 10^{-2}$  and  $2 \cdot 10^{-1}$  Torr, in which collisionless collective effects in the discharge plasma are apparently insignificant. It is found that the plasma resonance has a decisive influence on the threshold characteristics and dynamics of low-pressure discharges. A simple model is developed that agrees qualitatively with the experimental findings and that predicts correctly a weak relationship between the discharge velocity and the pressure far from the threshold. References 10: 9 Russian, 1 Western.

[386-6900/12955]

UDC 621.373.826:533.9

### SLOW COMBUSTION OF LASER PLASMA AND OPTICAL CHARGES

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 24 Jul 84)

FEDOROV, Vadim Borisovich, Institute of General Physics, USSR Academy of Sciences

[Abstract] Laser plasma is investigated in the region of moderate lasing intensities, where the electron heating rate in the radiation field is usually slower than the rate at which electrons lose energy, and the electron-ion relaxation rate. Slow laser plasma combustion is detected, in which an optical discharge plasma is maintained at minimum threshold intensity levels for the optical band, with subsonic propagation of the plasma and thermal ionization of the matter at the front of the discharge in the maintaining radiation field. The process of subsonic propagation of a slow combustion wave of laser plasma is interpreted theoretically. Steady-state unidimensional

propagation of a plane wavefront in a collimated laser beam is achieved, and new methods are developed for diagnosing gas motion in the region of subsonic optical discharge. A new method is developed for diagnosing a hot gas (plasma) on a target by measuring the parameters of the plasma near the front of the shockwave. A neodymium glass laser is developed which employs reflecting plasma as a nonlinear mirror in the optical cavity, and also as an optical shutter. References 7 Russian.  
[324-6900]

UDC 533.9.08

#### SPECTROSCOPY OF LABORATORY AND SPACE PLASMA WITH OSCILLATING ELECTRICAL FIELDS

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 18 Jul 84)

OKS, EVGENIY ALEKSANDROVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] The spontaneous emission spectra of atoms and ions interacting with oscillating electrical fields in a plasma medium are investigated theoretically. The use of these phenomena for plasma diagnosis under specific laboratory and space conditions is examined. The  $I(\Delta\omega)$  contours of the emitted lines are investigated as a function of the electrical field parameters (the amplitude, the position of the maximum and widths of the frequency spectrum, the degree of ellipticity or degree of spatial anisotropy), and of the plasma medium parameters (the electron concentration and temperature, the ion temperature, and the atom temperature). A theory is developed to explain broadening of atom and ion spectral lines in a plasma caused by two types of intra-plasma electrical fields simultaneously: quasimonochromatic and wideband. The simultaneous effect of the latter two types of fields on a coulomb radiator is investigated. A new nonlinear optical effect called 'dynamic resonance' is detected. A nonlinear theory for plasma and laser satellites of spectral lines in homogeneous and inhomogeneous plasma is developed. The plasma diagnostic methods developed are applied under laboratory conditions. A search program for oscillating electrical fields in space plasma is developed theoretically and carried out. References 34 Russian.  
[324-6900/12955]

## EQUILIBRIUM STATES OF CHARGED ELECTRON BEAMS AND SPACE CHARGE COMPENSATION PROCESSES

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) 1984 Dissertation Abstract, (signed to press 19 Oct 84)

MALAFAYEV, VLADIMIR ALEKSEYEVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] The equilibrium states and stability of a nonrelativistic electron beam in an external longitudinal magnetic field are investigated theoretically and experimentally. Possible equilibrium states of the electron beam with arbitrary cathode shielding is analyzed theoretically, and the theory is tested experimentally for the case of strong magnetic fields. The formation of a virtual cathode in the region in which the beam enters drift space is studied experimentally, as are the processes of compensation and stability of the quasi-steady-state of the beam. Three characteristic equilibrium regions with different geometric dimensions and beam energy characteristics are found. Extremal currents occur for a fixed magnetic field and fixed beam radiants, that increase in value as the magnetic field becomes weaker and the cathode shielding becomes greater. The branch of the state diagram corresponding to high kinetic energy is found to be stable. Instability occurs within the ionization time at low pressures, resulting in azimuthally inhomogeneous beam structure. References 4 Russian.  
[324-6900/12955]

CHARACTERISTICS OF MANDELSTAM-BRILLOUIN SCATTERING IN LASER PLASMA WITH MODERATE LIGHT FLUX DENSITIES OF  $10^{12}$ - $10^{14}$  W/cm<sup>2</sup>

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 88, No 3, Mar 85 (manuscript received 23 Aug 84), pp 781-788

ALEKSANDROV, V. V., BRENNER, M. V., KOVALSKIY, N. G., LOBUREV, S. V. AND RUBENCHIK, A. M.

[Abstract] The characteristics of radiation reflected and scattered by plasma occurring when nanosecond pulses from a neodymium laser strike solid flat targets are investigated on the Mishen'-1 system at the Institute of Atomic Energy imeni I. V. Kurchapov. The space-time and spectral characteristics of the scattered radiation are measured. The scattered radiation spectrum is found to broaden to 15-20 Å for light flux densities exceeding  $10^{13}$  W/cm<sup>2</sup>. The plasma is shown to be highly absorbing for normal incidence of the laser beam on the surface of the targets. Oblique incidence exhibits highly directional scattering in the aperture of the focusing lens. No spectrum broadening is observed for targets made of elements with high atomic numbers, which indicates that collisions play a decisive role under the experimental conditions. References 14: 7 Russian, 7 Western. Figures 5.  
[368-6900/12955]

# EXPANSION OF CLOUD OF RELATIVISTIC PROTONS IN MAGNETIZED PLASMA

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 88, No 3, Mar 85 (manuscript received 19 Sept 84), pp 789-797

KRUCHINA, Ye. N., SAGDEEV, R. Z. AND SHAPIRO, V. D., Institute of Space Research, USSR Academy of Sciences

[Abstract] The expansion of a cloud of relativistic protons in a cold magnetized plasma, accompanied by the generation of Alfvén oscillations, is investigated on the basis of quasilinear equations. A system of equations is derived for waves that are polarized in the direction of electron rotation in the magnetic field. Self-similar solutions are found for nonrelativistic and ultrarelativistic particles. Nonlinear mechanisms underlying the diffusion of resonant particles: Doppler broadening and the magnetic mirror mechanism are analyzed. References 6: 3 Russian, 3 Western. Figures 3. [386-6900/12955]

UDC 533.9.01

# ESTIMATES OF PARAMETERS OF HOT ELECTRONS DURING BEAM HEATING OF PLASMA IN A MAGNETIC FIELD

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85 (manuscript received 3 Aug 84 after revision), pp 387-393

BREYZMAN, B. N. AND YEROFEEV, V. I., Institute of Nuclear Physics, Siberian Department, USSR Academy of Sciences

[Abstract] The dynamics of high-energy electrons formed in Langmuir turbulence and excited in a plasma by a relativistic electron beam is examined. The density perturbations that cause waves to move from one region of the phase space to another, and to maintain balance between pumping and attenuation, are assumed to be generated by the high frequency pressure of the Langmuir waves themselves. A kinetic equation is derived for the excitation, attenuation, and elastic scattering of Langmuir waves. The concentration and characteristic energy of the hot electrons is found within the framework of the proposed model. The estimates are compared with the results of experiments conducted on the INAR and GOL-1 installations. References 13: 5 Russian, 8 Western. Figures 1. [405-6900/12955]

## CONDITIONS FOR STABILIZATION OF NEGATIVE ION BEAM ION-ION INSTABILITY

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 10 Sep 84 after revision), pp 394-399

GORETSKIY, V. P. AND NAYDA, A. P., Institute of Physics, Ukrainian SSR Academy of Sciences

[Abstract] Nonlinear amplitude of negative potential pulsations in a beam of ions is investigated experimentally in argon and hydrogen as a function of pressure. An intermediate state is found to exist for a negative ion beam in which the center is quasineutral, with a negative residual charge and small electron concentration, while the periphery is in a plasma state with positive charge and high electron concentration. Formulas are derived for the stabilization pressure over a wide range of experimental conditions. It is found that the stabilization pressure for ion-ion instability begins to decrease as the current of the negative ion beam increases beyond a certain value. The pressure ratio at the boundary of the band (within which the pressure can become smaller) increases as the molecular mass of the gas decreases. References 11: 10 Russian, 1 Western. Figures 6.  
[405-6900/12955]

## TWO-DIMENSIONAL KINETIC MODEL OF HYDROGEN MACROPARTICLE EVAPORATION IN A TOKAMAK

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 24 Jul 84), pp 409-416

KUTEYEV, B. V., UMOV, A. P. AND TSENDIN, L. D., Leningrad Polytechnical Institute imeni N. I. Kalinin

[Abstract] The evaporation of a fuel tablet in a plasma with Maxwell electron distribution by energy and angles is investigated. A formula is derived that approximates to within 10% the relationship between the evaporation rate and temperature, plasma density, and macroparticle radius. Most of the heat reaching the tablet is found to come from electrons at the tail of the distribution function with energies of  $(6-8) T_e$ . This accounts for the small influence of electrical fields near the surface on the evaporation rate. Experiments on injecting hydrogen macroparticles into a plasma at the T-10 Tokamak are described. References 15: 4 Russian, 11 Western. Figures 7.  
[405-6900/12955]

## OHM'S LAW AND HEAT TRANSPORT IN TURBULENT RELATIVISTIC PLASMA

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 8 Jun 84 after revision), pp 436-438

ARKHIPOV, Yu. V. AND BAIMBETOV, F. B., Kazakh State University imeni S. M. Kirov

[Abstract] The theory of transfer processes in a non-relativistic plasma with ion-sound turbulence is extended to the case of a relativistic plasma. A system of kinetic equations is derived for electrons and ion-sound quanta in the relativistic plasma with developed ion-sound turbulence. Formulas derived for the conductivity and the thermoelectric coefficient indicate that they are determined by the phase velocity of the ion-sound waves, as in a non-relativistic plasma. The influence of relativistic effects on current density and heat flow is analyzed. References: 7 Russian. Figures 2.  
[405-6900/12955]

## RELATIVISTIC EFFECTS DURING COMPTON INTERACTION OF STRONG ELECTROMAGNETIC RADIATION AND OPTICALLY THIN LAYER OF COLD PLASMA

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 5 Jun 84), pp 497-499

LYSIKOV, Yu. I., Voroshilovgrad Machine Building Institute

[Abstract] The development of plasma oscillations when a strong electromagnetic radiation flux interacts with an optically thin layer of cold plasma is analyzed. A hydrodynamic description of the dynamics of a cold two-component (singly-charged ions and electrons) plasma in a strong electromagnetic radiation field with induced Compton quantum scattering by electrons predominating is used in the analysis. Examples of such systems include objects in space, such as the plasma near pulsars and quasars. A one-dimensional case is examined, assuming an initial uniform electron and ion distribution throughout the entire space. A process of exponential growth of plasma oscillations is found analytically. References: 2 Russian.  
[405-6900/12955]

## PLASMA FLOWS IN DIVERTOR REGIONS OF "VINT-20" SINGLE-PASS TORSATRON

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 28 May 84), pp 500-504

BOCHAROV, V. K., VOLKOV, Ye. D., LESNYAKOV, G. G. AND YUFEROV, V. B.,  
Kharkov Physical-Technical Institute, USSR Academy of Sciences

[Abstract] Plasma flows are investigated along and across the helical divertor magnetic slot in a single-pass Torsatron with a spatial magnetic axis and highly inhomogeneous magnetic field along the line of force. Well-formed plasma jets are shown to occur in the region behind the separatrix, indicating the fundamental possibility of achieving a divertor configuration. The width of the divertor flows is no more than one twentieth that of the last closed magnetic surface. The plasma flows along the divertor slot increase in magnitude in the direction of the outer part of the torus. References 11: 4 Russian, 7 Western. Figures 6.  
[405-6900/12955]

## ENERGY CONFINEMENT TIME AS FUNCTION OF LARGE RADIUS IN T-13 TOKAMAK

Moscow FIZIKA PLAZMY in Russian Vol 11, No 4, Apr 85  
(manuscript received 30 Aug 84), pp 505-506

ABRAMOV, A. V., BELASHOV, V. I., BORTNIKOV, A. V., BREVNOV, N. N., GERASIMOV, S. N., KORNEEV, S. V., KUZNESTOV, N. V., MAKASHIN, I. N., PERGAMENT, V. I., KHARITONOV, A. N., KHIMCHENKO, L. N. AND TSEPAKIN, I. A., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] The energy of confinement time is investigated experimentally as a function of the large radius in the T-13 Tokamak. The radiation energy losses do not exceed 20%, and the transfer of energy from electrons to ions does not exceed 5% of the Joule heat. The lifetimes of the charged particles exceeds the confinement time by approximately an order of magnitude. There is found to be no relationship, within the accuracy limits of the experiment, between the energy confinement time in the electron component and the large radius of the plasma filament. References 3: 1 Russian, 2 Western. Figures 2.  
[405-6900/12955]



## INFLUENCE OF PLASMA DENSITY IN HOMOGENEITY ON ITS RESPONSE TO PULSE SOUNDING

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3: FIZIKA ASTRONOMIYA in Russian Vol 26, No 2, Mar-Apr 85 (manuscript received 13 Aug 84), pp 42-44

KUZOVNIKOV, A. A., SVIRIDKINA, V. S., SUKHOV, A. K. AND TARASOVA, V. V.

[Abstract] The behavior of plasma perturbed by an external pulse voltage source is studied; the influence of inhomogeneity of the plasma density on the perturbations that occur is analyzed. The experiments were conducted in argon in a glass tube containing cylindrical zones for determining the parameters of the plasma itself. The discharge current ranged from 0.5 to 10 mA, the electron density was approximately  $10^8 \text{ cm}^{-3}$ , and the electron temperature was approximately 5 eV. No ion sound waves were excited at pressures ranging from  $10^{-2}$  to  $10^{-1}$  Torr. The voltage pulse front created perturbations at pressures exceeding  $10^{-1}$  Torr, with frequency and length independent of the amplitude of the applied pulse. The presence of an HF field was found to increase the discharge current by 2%, as well as the plasma density across the entire cross-section of the tube. The inhomogeneous plasma density along the axis of the tube and the increased radial concentration gradient caused additional losses of charged particles due to ambipolar diffusion.

References 3: 2 Russian, 1 Western. Figures 3.

[389-6900/12955]

## COLLISION AND RADIATION PROCESSES IN LOW-TEMPERATURE PLASMA INVOLVING HIGHLY-EXCITED ATOMIC AND MOLECULAR STATES

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) 1984 Dissertation Abstract in Russian (signed to press 12 Mar 84)

LEBEDEV, VLADIMIR SERGEYEVIIY, Institute of General Physics, USSR Academy of Sciences

[Abstract] Elementary collision and radiation processes occurring in gas and plasma involving strongly-excited states of atoms, molecules and molecular ions are investigated theoretically. Simple analytical expressions are derived for the probabilities, cross-sections and velocity constants of these processes. A quasi-classical model is proposed that makes possible analytical calculations of the nuclear matrix elements for the dipole moment of diatomic molecules and ions during transitions between states of continuous and discrete spectra close to the dissociation boundary. Inelastic transitions, as well as direct and associative ionization of highly excited atoms caused by collision between a neutral particle and its atomic trunk are analyzed theoretically. The proposed mechanism underlying inelastic transitions is shown to explain experiments on the extinction of NS atomic levels for alkali metals in inert gases. References 8 Russian.

[324-6900/12955]

## ELECTRICAL DISCHARGE WITH OPEN ELECTRON DRIFT

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract (signed to press 23 Jan 84)

RYBALOV, SERGEY VIKTOROVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] This study investigates the ignition physics and steady-state physics of electrical and magnetic fields with open drift, in which the length of the electron drift trajectory on which charged particle propagation is possible is limited in some way, so that the electrical strength is higher than in a geometry with closed drift, but lower than on Paschen's left branch. It is shown that the ignition of an independent discharge with open electron drift follows Townsend's scheme, in which a cathode photo-effect caused by Bremsstrahlung from the anode is the factor that facilitates electronic avalanche reproduction. The elapsed time between activating hybrid fields and discharge ignition is determined. Ignition curves, which exhibit high-voltage and low-voltage branches, are determined for a wide spectrum of experimental parameters. The processes occurring in the plasma of a quasi steady-state discharge are analyzed theoretically. The analytical results agree well with the experimental findings. References 5 Russian.  
[324-6900/12955]

## PLASMA MECHANISM UNDERLYING HIGH PRESSURE GAS BREAKDOWN

Moscow AKADEMIYA NAUK SSSR INSTITUT OBSHCHEY FIZIKI (Na pravakh rukopisi: Avtoreferat) in Russian 1984 Dissertation Abstract, (signed to press 27 Sep 84)

BROYTMAN, ALEKSANDR PETROVICH, Institute of General Physics, USSR Academy of Sciences

[Abstract] The breakdown of gases at high pressure (atmospheric or higher) in strong electrical fields - 'spark' or 'streamer' breakdown - is investigated in order to establish the mechanism underlying the formation of streamer breakdown and to create an adequate theoretical model. Streamer breakdown is divided into three stages: in the first, thermal fluctuations of the homogeneous electron background build up over time and cause distortion of the external magnetic field. In the second stage, the electrical field drops due to longitudinal Debye shielding, resulting in abrupt cooling of the electrons and strong recombination. In the third stage, secondary avalanches, which distort the electrical field as they develop, cause a rapid increase in the plasma region near the electrodes, i.e., streamer propagation. The experimentally observed similarity law  $\alpha d \sim 20$  is confirmed by the proposed theory. The quantity  $\alpha d$  is a logarithmic function of the intensity of the external electrical field and the number of initial electrons causing ionization avalanche. References 11 Russian.  
[324-6900/12955]

## SUPERCONDUCTIVITY

UDC 535.231.15:537.312.62

### NONLINEAR PROPERTIES OF SUPERCONDUCTING POINT CONTACTS AND PROSPECTS FOR USE IN QUANTUM ELECTRONICS

Kiev KVANTOVAYA ELEKTRONIKA in Russian Vol 27, Oct 83 (manuscript received 30 May 83), pp 3-37

DANILENKO, M. V., DERKACH, V. E., BELENOV, E. M., ROMANENKO, V. I., USKOV, A. V., Institute of Physics, Ukrainian SSR Academy of Sciences

[Abstract] The nonlinear properties of superconducting point contacts employed in electrodynamic systems, such as resonators or waveguides, are examined. Two cases are investigated: one in which the currents of the superconducting contact interact only with the fields excited by the contact itself in the resonator or waveguide, and one in which microwave and optical radiation are applied simultaneously or alternately to the contact from without. The study is based on Maxwell's equations for an electromagnetic field in a system incorporating a contact, as well as the material equations describing the contact properties. The multiplicative and mixing properties of superconducting point contacts are investigated. The possibility of developing induced radiation sources and frequency synthesizers operating between the microwave and optical bands based on Josephson junctions is investigated. References: 47, 26 Russian, 21 Western. Figures: 13. [395-6900/12955]

METHOD FOR CONSTRUCTING EQUIVALENT AND  $\epsilon$ -EQUIVALENT PROBLEMS WITH ONE  
CONSTRAINT FOR A NONLINEAR DISCRETE-PROGRAMMING PROBLEM

Baku DOKLADY AKADEMII NAUK AZERBAYDZHANSKOY SSR in Russian Vol 41, No 3, Mar 85  
(received 15 Jul 82) pp 11-14

[Article by A. A. Aliyev and K. Sh. Mamedov, Institute of Cybernetics, Academy  
of Sciences of the Azerbaydzhan SSR]

[Text] The difficulty of solving the general problem of discrete programming, even in the case of linear problems, is well known [2,4,5,6]. At the same time, quite efficient methods are available for solving problems with one constraint [3]. Hence it is desirable to construct a method in which the solution of the general problem of discrete programming would reduce to the solution of some problem with one constraint. Such a method for linear integer-programming models is constructed in [1]. The following questions must be resolved in order to implement this method:

a) the existence of a discrete-programming problem with one constraint, for which the set of optimal ( $\epsilon$ -optimal) solutions contains a set of optimal ( $\epsilon$ -optimal) solutions of the starting problem, must be established; and

b) a method must be developed for constructing such a problem.

In this paper, we introduce the concept of equivalence ( $\epsilon$ -equivalence) of two discrete-programming problems. It is shown that under certain conditions an equivalent ( $\epsilon$ -equivalent) problem with one constraint exists and a method for constructing it is developed.

Consider the problem

$$\max \{f(X) \mid \varphi_i^0(X) < b_i^0, i = 1, 2, \dots, m, X \in G\} \quad (1)$$

Here  $X = (x_1, x_2, \dots, x_n)$ ,  $G$  is some finite set,  $b_i^0$  ( $i = 1, 2, \dots, m$ ) and  $x_j$  ( $j = 1, 2, \dots, n$ ) are real, and  $f(X)$  and  $\varphi_i^0(X)$  are scalar functions defined on the set  $G$ .

Starting from (1), we construct the following problem:

$$\max \{f(X) \mid \varphi^0(X) \leq b^0, X \in G\}. \quad (2^0)$$

Here

$$\varphi^0(X) = \sum_{i=1}^m \varphi_i^0(X), \quad b^0 = \sum_{i=1}^m b_i^0.$$

Definition 1. Of the two discrete-programming problems (1) and (2°) with the same target function, the problem (2°) is said to be equivalent ( $\epsilon$ -equivalent) to the problem (1), if the set of optimal ( $\epsilon$ -optimal) solutions of the problem (1) is contained in the set of optimal ( $\epsilon$ -optimal) solutions of the problem (2°).

Let  $X^0$  be the optimal solution of the problem (2°). It is evident that if  $X^0$  is an admissible solution of the problem (1), then it will be an optimal solution of this problem, and therefore the problem (2°) will be an equivalent problem. Let  $X^0$  be inadmissible for problem (1). Then the problem (2<sup>1</sup>) is constructed using the method proposed below and the process is repeated.

We introduce the following definition.

Definition 2. We call the process of finding an optimal solution to a problem of the type (2 <sup>$\kappa$</sup> ) ( $\kappa = 0, 1, 2, \dots$ ) an iteration (or the  $\kappa$ -th iteration).

We define the number  $\tau_{i_\kappa}$  as follows:

$$\tau_{i_\kappa} = (b_{i_\kappa}^{\kappa} - \varphi_{i_\kappa}^{\kappa}(X^{\kappa})) / (\varphi_{i_\kappa}^{\kappa}(X^{\kappa}) - b_{i_\kappa}^{\kappa}) + 1.$$

Here  $X^{\kappa}$  is the optimal solution of the problem (2 <sup>$\kappa$</sup> ) at the  $\kappa$ -th iteration,

$$\varphi_{i_\kappa}^{\kappa}(X^{\kappa}) - b_{i_\kappa}^{\kappa} = \max_{i \in J^{\kappa}} [\varphi_i^{\kappa}(X^{\kappa}) - b_i^{\kappa}], \quad J^{\kappa} = \{i \mid \varphi_i^{\kappa}(X^{\kappa}) > b_i^{\kappa}\}.$$

Then the following theorem holds.

Theorem 1. a)  $\tau_{i_\kappa} \geq 1$ . b) If  $X^{\kappa}$  is inadmissible for the problem (1), then it strictly satisfies at least one of its inequalities.

We multiply the inequality  $i_\kappa$  from (1) by  $\tau_{i_\kappa}$  and rewrite the functions and



Corollary. If at each iteration the factors  $t_{i_v}$  ( $v = 0, 1, 2, \dots$ ) are determined from the system of linear inequalities (3), then an optimal solution of the problem (1) is obtained within a finite number of iterations, i.e., an equivalent problem of the type  $(2^K)$  exists and it can be constructed within a finite number of iterations.

This follows from the finiteness of the set  $G$  and from theorem 3.

It should be noted that in the course of the solution the coefficients in the constraints of the problems  $(2^K)$  ( $K = 0, 1, 2, \dots$ ) can grow and become significant. On the other hand, the values of the functional of the problems  $(2^K)$  ( $K = 0, 1, 2, \dots$ ) may not vary monotonically. To eliminate these defects, we construct the following problem:

$$\max \{f(X) \mid \varphi_i^K(X) \leq b_i^K, i = 1, 2, \dots, m; f(X) < \bar{\Phi}, X \in G\}. \quad (4^K)$$

Here  $\bar{\Phi}$  is the upper limit of the optimal value of the functional of the problem (1). Let  $\bar{\Phi}$  be an integer. Starting from the problems  $(4^K)$ , we construct the following problem of the type  $(2^K)$ :

$$\max \{f(X) \mid \psi^K(X) \leq \tau^K, X \in G\}, \quad (5^K)$$

where

$$\psi^K(X) = \sum_{i=1}^m \varphi_i^K(X) + \tau^K f(X), \tau^K = \sum_{i=1}^m b_i^K + \tau^K \bar{\Phi}.$$

We denote by  $\Phi$  the optimal value of the function of the problem  $(5^K)$ . The following theorem then holds.

Theorem 4. Let the function  $f(X)$  assume integer values for  $X \in G$ . Then if  $\tau^K > b^K - \xi^K + 1$ , then  $\Phi \leq \bar{\Phi}$ , where  $\xi^K \leq \min_{X \in G} \Phi^K(X)$ .

We note that application of theorem 4 at each iteration guarantees that a monotonic nonincreasing sequence of upper limits on the optimum of the problem (1) is obtained.

Thus the problem (1) can be solved by the following algorithm.

#### Algorithm 1

Step 1. Set  $K := 0$  and proceed to step 2.

Step 2. Construct the problem (5<sup>κ</sup>) and find its solution X<sup>κ</sup>. Go to step 3.

Step 3. If X<sup>κ</sup> is admissible for the problem (1), then it will be the solution of the starting problem and the process terminates. If X<sup>κ</sup> is an inadmissible solution of the problem (1) and  $\bar{\Phi} > \Phi$ , then set  $\bar{\Phi} := \Phi$  and go to step 1. Otherwise proceed to step 4.

Step 4. Determine from the system (3) the factors  $t_{i_v}$  ( $v = 0, 1, \dots, \kappa$ ), and set  $\kappa := \kappa + 1$  and go to step 2.

It should be noted that if  $X^{\kappa} = (x_1^{\kappa}, x_2^{\kappa}, \dots, x_n^{\kappa})$  is an  $\epsilon$ -optimal solution of the problem (2<sup>κ</sup>) on the  $\kappa$ -th iteration ( $\kappa = 0, 1, 2, \dots$ ), i.e., the condition  $(\bar{f}_{\kappa} - f(X^{\kappa})) / |\bar{f}_{\kappa}| \leq \epsilon$  holds, and X<sup>κ</sup> is admissible for the problem (1), then it will also be an  $\epsilon$ -optimal solution of this problem, since

$$(\bar{f} - f(X^{\kappa})) / |\bar{f}| \leq (\bar{f} - f(X^{\kappa})) / |\bar{f}_{\kappa}|,$$

where  $\bar{f}$  and  $\bar{f}_{\kappa}$  are upper limits of the optimum of the problems (1) and (2<sup>κ</sup>), respectively, and  $\epsilon > 0$  is the fixed accuracy. It is assumed here that either  $0 \leq f(X^{\kappa}) \leq \bar{f} \leq \bar{f}_{\kappa}$  or  $f(X^{\kappa}) \leq \bar{f} \leq \bar{f}_{\kappa} < 0$ .

If X<sup>κ</sup> is inadmissible for the problem (1), then the theorems 1, 2, and 3 presented above still hold when X<sup>κ</sup> ( $\kappa = 0, 1, 2, \dots$ ) is the  $\epsilon$ -optimal solution of the problem (2). Then the  $\epsilon$ -optimal solution of the problem (1) can be determined by the following algorithm.

#### Algorithm 2

Step 1. Set  $\kappa := 0$  and go to step 2.

Step 2. Construct the problem (2<sup>κ</sup>) and find its  $\epsilon$ -optimal solution X<sup>κ</sup>. Go to step 3.

Step 3. If X<sup>κ</sup> is admissible for the problem (1), then it will also be an  $\epsilon$ -optimal solution of this problem and go to step 5. Otherwise go to step 4.

Step 4. Determine from the system (3) the factors  $t_{i_v}$  ( $v = 0, 1, \dots, \kappa$ ), and set  $\kappa := \kappa + 1$  and go to step 2.

Step 5. End.



Thus the following basic theorem holds.

Theorem 5. If a nonnegative solution exists at each iteration  $p$  ( $p = 0, 1, 2, \dots$ ) of the system (3), then there exists an equivalent ( $\epsilon$ -equivalent) problem of the type  $(2^K)$  and the algorithms 1 and 2 provide a method for constructing these problems, respectively.

In conclusion, the authors are deeply grateful to Dzh. A. Babayev for discussions and valuable suggestions.

#### BIBLIOGRAPHY

1. Aliyev, A. A., "A new approach to the solution of integer-programming problems," *IZV. AN AZERB. SSR, SERIYA FIZ.-TEKHN. I MATEM. NAUK*, No 1, 1980, pp 140-146.
2. Akho, A., Khopkroft, Dzh., and Ul'man, Dzh., "Postroyeniye i analiz vychislitel'nykh algoritmov" [Construction and Analysis of Computational Algorithms], Moscow, Mir, 1979.
3. Veliyev, G. P. and Mamedov, K. Sh., "Method for solving the knapsack problem," *ZhVM i MP*, No 3, 1981, pp 605-611.
4. Emelichev, V. A. and Komdik, V. I., "Metod postroyeniya posledovetel'nosti planov dlya resheniya zadach diskretnoy optimizatsii" [Method for Constructing Sequences of Plans for the Solution of Discrete-Optimization Problems], Moscow, Nauka, 1981.
5. Kovalev, M. M., "Diskretnaya optimizatsiya [Discrete Optimization], Minsk, BGU, 1978.
6. Finkel'shteyn, Yu. Yu., "Priblizhennyye metody i prikladnyye zadachi diskretnogo programmirovaniya" [Approximate Methods and Applied Problems in Discrete Programming], Moscow, Nauka, 1976.

COPYRIGHT: Izdatel'stvo "Elm", 1985

9638

CSO: 1862/398

## USE OF SPECTRAL SYSTEMS RUN COEFFICIENTS FOR SPECTRAL ESTIMATION OF SOME MATRICES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 281, No 6, Apr 85  
(manuscript received 28 Apr 84) pp 1303-1307

ISMAILOVA, N. A. AND KONDRASHOV, V. E.

[Abstract] A new method for determining the stability of a finite-difference scheme for a one-dimensional heat-conduction equation was constructed. The method can be used in situations when the standard techniques of stability analysis are not applicable, as well as for more complicated equations. The method is based on the use of the run coefficients  $\bar{\mu}_j(\lambda)$  and  $\bar{\mu}_j^*(\lambda)$  of spectral systems, where the arrow indicates the direction of the run and  $\lambda$  is the spectral parameter. It was shown that the coefficients  $\mu$  and  $\mu^*$  satisfy an equation of the form  $\mu_M(\lambda) = K(\lambda)$  where  $M$  is the maximum value of the iteration index  $j$  and the function  $K$  has the form  $K(\lambda) = (\lambda - a)/b$ . It was shown that this equation has  $M$  different finite real solutions  $\lambda_1, \dots, \lambda_M$  which comprise the spectrum of the matrix and that this equation has no other solutions. The examples for a finite-difference analogue of a heat conduction equation with constant and variable coefficients were analyzed in detail. References 3: all Russian.

[406-9638/12955]

## HIGH PRECISION ALGORITHMS FOR SOLVING FIRST ORDER INTEGRAL EQUATIONS

Moscow ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 25, No 4, Apr 85 (manuscript received 12 Oct 84 after revision), pp 512-520

KOROVCHKIN, A. Ye., MARCHENKO, N. A. AND PERGAMENT, A. KH.

[Abstract] The problem of defining the unknown function  $z(t)$ ,  $t \in [0, T]$  from the relationship  $Az(t) = u(t) + \Delta(t)$  is examined, where  $A$  is a completely continuous linear operator and  $\Delta(t)$  is a stationary random Gaussian process with mean of 0 and correlation operator  $B$ . In the process  $\Delta(t)$  is a linear functional of a generalized random process with constant spectral density. A solution algorithm is proposed based on parametric representations of the sought functions that are optimal in terms of information. The accuracy of the approximation is of the same order of magnitude for compacts as the Kolmogorov diameter of the corresponding sets. The asymptotic behavior of the minimum number of parameters as  $N$  approaches infinity is examined, and the convergence of the regularization method is analyzed. Computational experiments to verify the proposed algorithms are described. The use of approximations of the solution that are optimal for information makes it possible

to obtain a high precision algorithm for solving first order integral equations: first, because the number of parameters to be defined is much smaller than the number of right samples and, second, because statistical criteria are used in selecting the regularization parameter. References 16: 15 Russian, 1 Western. Figures 3.  
[388-6900/12955]

UDC 519.676

TWO-GROUP OPTIMIZATION FOR METHOD OF STATISTICAL MODELING OF RADIATION FIELD FOR HYDROGEN CONTAINING MEDIA

Moscow ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 25, No 4, Apr 85 (manuscript received 28 Feb 84), pp 588-598

YERMAKOV, S. M. AND KARYUKIN, V. V.

[Abstract] The construction of "fictitious models" to solve N group problems (NG optimum models,  $N > 1$ ) for fast-neutron transfer is examined. Small-group model equations of transfer theory are constructed and solved to make allowance for the Monte Carlo method. The solutions obtained for  $N=2$  make it possible to validate algorithms derived previously by one of the authors. Asymptotic optimization (NGA-optimal algorithms) are investigated. Simulation performed on a BESM-6 computer is described. The approach can also be used for optimization of other problems, for example, 2GA-optimization of the statistical modeling method, can be used for heavy media allowing for inelastic scattering. References 13: 12 Russian, 1 Western. Figures 1.  
[388-6900/12955]

LETTER TO THE EDITOR IN RESPONSE TO ARTICLE ENTITLED "ESTIMATION OF FUNCTION BY RANDOMIZED OBSERVATIONS"

Moscow ZHURNAL VYCHISLITELNOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 25, No 4, Apr 85, pp 634-635

KORYAKIN, A. I.

[Abstract] This letter to the editor points out that the title article, which was published in Zhurnal Vychislitelnoy Matematiki i Matematicheskoy Fiziki, 1983, Vol 23, No 1, pp 21-28, erroneously estimated the probability of convergence of matrix (9) to the identity matrix, which becomes smaller as the order of the matrix increases, in determining the order of the accuracy of the estimate of  $\pi(3, m, x)$ . An assertion which is weaker than the one proposed in the original study is proposed.  
[388-6900/12955]

DISSIPATIVE STRUCTURES IN LASER RADIATION FIELD

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49,  
No 3, Mar 85, pp 528-535

KIRICHENKO, N. A., Institute of General Physics, USSR Academy of Sciences

[Abstract] Stable steady states of a gas in a continuous laser radiation field are examined. An algorithm is presented for investigating the stability of steady-state solutions to a nonlinear boundary-value problem. The linear theory of stability is found to facilitate stable candidate decisions (for which the increase in the perturbations or their stabilization are non-exponential). Problems are identified in which the linear theory of stability makes it possible to identify the stable state unambiguously. The algorithm can be extended to boundary-value problems with complex eigenvalues.

References: 12 Russian. Figures 3.

[382-6900/12955]

- END -